Direct Contact Condensing Heat Recuperator

CANADA PACKERS INC. — WINNIPEG, MANITOBA

Technology:
Heat recovery from flue gas

Demonstration Project Manager:
J.M. Magro, P.Eng.
Plant Mechanical Supervisor
Canada Packers Inc.
660 Marion Street
Winnipeg, Manitoba
R3C 2G8
(204) 237-9811

Location:
Winnipeg, Manitoba

Annual Savings: $141,000
9.5% of boiler fuel costs

Payback Period: 2-3 years
(for continuous operation)

Applicable to:
Industrial, Commercial and Institutional users of large quantities of hot water produced by natural gas fired boiler:

- Food processing industry
- Textile industry
- Synthetic fibre manufacturers
- Pulp and paper industry
- Soap and detergent production
- Steel pickling operations
- Mining mills
- Industrial washing applications
- Institutions
- Recreational and sports facilities

Description:
A Direct Contact Heat Recuperator, using a new approach to the recovery of latent heat from natural gas flue gases, was installed and monitored for six months by Canada Packers' Winnipeg plant.

This condensing heat recovery system, designed and manufactured by John Thurley Ltd. of Harrowgate, England, using Canadian-produced parts, recovers waste heat from the boiler exhaust by spraying water on the hot flue gases, then transferring the heat from the spray water to the plant process water supply.

The monitoring program at Canada Packers showed significant improvement in boiler efficiency and reduced fuel consumption, while still meeting the plant's pre-heated potable water requirements for processing, sanitation and boiler feed.

The Direct Contact Condensing Heat Recuperator is shown to the left of the large stack.

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Benefits:

- Over four times more available waste heat from natural gas flue gases can be recovered by a condensing heat recovery system than by conventional systems.
- Overall efficiency of the boiler system increased by 10.4% from 81.8% to 92.2%
- The improved overall efficiency and reduced steam requirements yielded projected annual savings of approximately 1.1 million m^3 of natural gas fuel worth approximately $157,000 per year.
- Condensing heat recovery systems are useful to many industries using natural gas and requiring large quantities of hot water.

Performance:

The condensing heat recovery system's satisfactory performance was demonstrated over a six-month monitoring period.

- On average the unit recovers about 70% of the heat that previously had been exhausted in the flue gases. This is high for any recovery system. The corresponding heat recovery rate averaged 4.02 GJ/hour (3.81×10^6 Btu/hr), which is equivalent to 10.4% of the boiler's fuel consumption.
- Optimum fuel savings were reached by operating the recuperator and boiler continuously. (Monitoring of recuperator operating hours is now a routine shift responsibility of the duty stationary engineer for rapid detection and correction of operating problems.) From a low utilization of 60% during the first seven weeks of the monitoring period, the rate has been improved to over 88% on a consistent basis.
- The superior performance of the condensing heat recovery system over conventional systems is partially offset by its greater cost. This is due to the larger size of its heat transfer surface and the extensive use of corrosion-resistant materials, necessary due to acidic compounds in the system.
- Excessive downtime was noticeable during the first two months after startup, due to winter freezing of the flue gas control dampers. (This was caused by moisture in the compressed air lines of the pneumatic damper control system.) Installation of an air dryer on the air supply system corrected this problem.
- Corrosion problems, due to contact with acidic solutions, developed with the original water recirculation pumps after four months of operation. This was solved by installing stainless steel pumps. No further corrosion problems have been reported after the first two years of operation.
- Justification for the extra cost of condensing heat recovery systems depends largely on the price of fuel at the particular site. Each potential installation should be evaluated on its own merits.

Technical Details:

A 1981 investigation convinced Canada Packers Inc. that the cost of recovering waste heat from the three boilers at its Winnipeg packing house was justified.

A comparative analysis showed that overall combustion efficiency could be increased from 80%, with no heat recovery, to 84.1% with a conventional system and to 96.3% with a condensing heat recovery system. The corresponding estimated rates of heat recovery were 0.0%, 20.5% and 81.5% of the potential waste heat.

Despite the higher capital cost, the superior heat recovery capability of the condensing system made it the most cost effective.

The chosen system was a Thurley Direct Contact Heat Recuperator designed by John Thurley, Harrowgate, England and manufactured by Thurley Enercon of Winnipeg. It was commissioned in September 1982, and its performance was monitored for the following six months.

As illustrated in the schematic diagram, a damper was installed in the breeching of the steam plant's boiler stack and new breeching was constructed to divert flue gases through an induced draft fan, to the lower section of the recuperator. A piping loop for heated recirculating water, a plate heat exchanger and a pre-heated process water storage tank completed the installation.

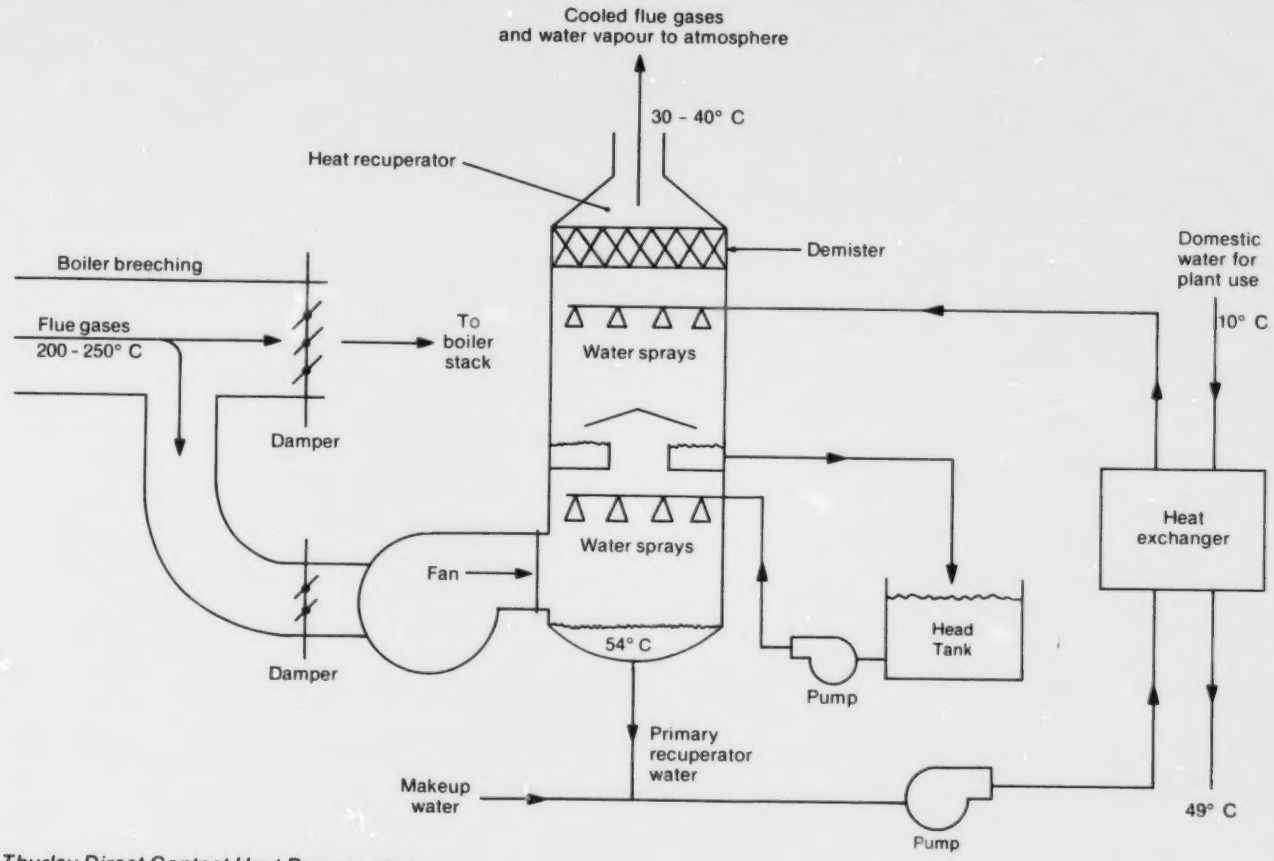
The recuperator recovers heat from flue gases by exposing them to direct contact with cold water sprays. During operation, the flue gases bypass the boiler stack and are forced through the recuperator by the induced draft fan. The cold water sprays cause the water vapour in the flue gas to condense, releasing its latent heat of vapourization to the water spray. The latent heat provides about half of the heat recovered by the recuperator, the remainder being due to sensible heat transfer. The flue gas temperature is reduced from 215° C (419° F) to 30° C (86° F) in the recuperator.

The recirculation water leaves the recuperator at about 54° C (129° F), under optimum conditions, and flows through a plate exchanger and back to the recuperating spray system. The clean, incoming fresh water is preheated from 10° C (50° F) to 49° C (120° F) in the exchanger and is further heated with live steam for use in plant processes, sanitation and boiler makeup. An outdoor tank with a capacity of 21,200 m^3 (21.2×10^6 litres) provides storage for excess process water preheated during the night shift and on weekends.

The recirculating water flow rate can be manually or automatically controlled to maintain a maximum temperature of 54° C (129° F) in the base of the recuperator. The flow rate is also controlled above a minimum allowable level for efficient spray contact action and quenching of the flue gases. This maintains heat recovery efficiency even when reduced boiler load lowers the recirculating water temperature.

The pH level in the recirculating water is maintained above pH 4.0 by continuous dilution with makeup water in the recuperator's head tank. This reduces acidity which is still strong enough to require such corrosion-resistant materials as stainless steel in the recuperator's lower section and fiberglass-reinforced plastic in its stack and flue gas outlet.

From both technical and economical standpoints, the condensing heat recovery system has justified the original decision of Canada Packers Inc. to install it.



Thurley Direct Contact Heat Recuperator

Economic Analysis:

Project Capital Costs:

Recuperator and Controls	$225,000
Installation and Auxiliaries	175,275
Total Installed Cost	$400,275

Annual Operating and Maintenance Cost:

Pre-demonstration fuel costs:		
($10{,}538 \times 10^3$ m³ natural gas @ $145.78/$10^3$ m³) =		$1,536,230
Post-demonstration fuel costs:		
($8{,}766 \times 10^3$ m³ natural gas @ $152/$10^3$ m³) =	$1,379,220	
Electricity for auxiliaries	12,000	
Maintenance costs	4,300	
Annual Post-demonstration costs	$1,395,520	$1,395,520
Net Annual Savings		$ 140,710

Simple Payback Period: 2.84 years.

Availability:

The demonstration unit was designed by John Thurley Ltd. of Harrowgate, England. Components were manufactured in Canada by Thurley Enercon Ltd. of Winnipeg. Other suppliers may provide similar equipment.

Site engineering was provided by Canada Packers' engineering department. Organizations without their own engineering departments may engage qualified engineering consultants to assist in acquiring and installing such systems.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Energy Information Centre
  Manitoba Energy and Mines
  117-234 Donald Street
  Winnipeg, Manitoba
  R3C 1M8
  (204) 945-4154

Information on the demonstration project is also available from the supplier:

- Thurley Enercon Ltd.
  (re: ENEROPTIONS)
  1329 Niakwa Road
  Winnipeg, Manitoba
  R2J 3T4
  (204) 257-3891
  Attn: Mr. E. Robertson

Heat Recovery and Insulation for a Cold Storage Facility

WESTCO STORAGE LTD. — PORTAGE la PRAIRIE, MANITOBA

Technology:
- Waste heat recovery from refrigeration facilities
- Insulation of cold storage buildings

Demonstration Project Manager:
General manager
Westco Storage Ltd.
301-3rd Street N.E.
Portage la Prairie, Manitoba
R1N 1P5

Location:
Portage la Prairie, Manitoba

Annual Energy Cost: $0.38/m³ ($0.01/ft³) (24% of the cost in previous building).

Applicable to:
New refrigeration facilities:
- Meat and poultry processors
- Fruit and vegetable processors
- Beverage producers
- Fish packers

Description:
Westco Storage Ltd. used a range of energy conservation measures in their new cold storage building and reduced their energy consumption by 76% compared with their old facility.

The cold storage warehouse, rebuilt in 1980 after a fire, and expanded in 1982, introduced a system which reclaims waste heat from the refrigeration unit. Incorporated into the design are special insulation and building techniques to conserve energy.

Waste heat from the hot compressed ammonia refrigerant is reclaimed and transferred through heat exchangers to recirculating systems. Recovered heat is supplied to the dry storage and loading dock areas. As well, a hot glycol solution circulates under the floor of the cold storage rooms to prevent frost formation. In summer, excess heat is discharged through an outside evaporative condenser.

Benefits:
- Energy costs per unit of volume in the new building are only 24% of those incurred in the old building.
- Spoilage of stored products is practically eliminated as high insulation levels guard against the impact of power failures.
- Defrosting times are greatly reduced.

Performance:
- Energy consumption in the new warehouse is $0.376/m³ ($0.0106/ft³) while consumption in the old building amounted to $1.589/m³ ($0.045/ft³).
- Energy costs and system performance were monitored for a twelve-month period. No major problems were encountered.

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- The vapour barrier and insulation in the wall panels reduce defrosting to twice per week for 30 minutes, compared with three times daily for 45 minutes in the old warehouse.
- High pressure sodium lighting installed in the storage areas provides adequate illumination and reduces costs.
- The rail shelter constructed on the north side of the building provides good protection from wind during winter and reduces heat loss.

Technical Details:

Westco Storage Limited has operated storage warehouses in Portage la Prairie, primarily for locally-grown vegetables, for a number of years. The initial phase of a new facility, 12,300 m² (132,330 ft²) in size was completed in 1981 followed by an expansion of 3,950 m² (42,500 ft²), completed in 1982.

The annual energy costs for natural gas and electricity in the old building totalled $45,223. Westco was determined to substantially reduce these costs per unit volume in the new, larger facility. This was accomplished by incorporating higher than normal insulation standards and by the recovery of heat from the refrigeration system.

The system parameters of the individual areas in the new building include:

	Capacity (m^3)	Temp. (°C)
Freezer	91,180	-20.5
Cooler	2,831	2.8
Heated Storage	28,883	16.7
Loading Dock	4,520	10.0
Office and other	2,265	21.1
	129,679 m^3	

The building insulation includes the following components:

- The grade beam for the building's slab-on-grade foundation is insulated with RSI 1.4 (R 8) rigid polystyrene foam insulation.
- Walls of the heated storage and loading dock are pre-finished metal cladding with RSI 3.7 (R 21) of fibreglass batting insulation. The roof over these areas and the cooler is the same construction with RSI 5.3 (R 30) insulation. The heavy-duty vinyl interior finish of the fibreglass batting provides an air-vapour barrier.
- The walls of the freezer and cooler are RSI 6.7 (R 38) urethane sandwich panels manufactured by Coldstream Products of Canada Ltd. They are 4 1/8 in thick and are covered on both sides with 28 gauge pre-finished metal to provide a good vapour barrier. The freezer roof is metal decking with a six-inch topping of foamed-in-place urethane insulation (RSI 8.0). A 42 mil rubber coating was applied in three coats over the urethane to provide the exterior surface.

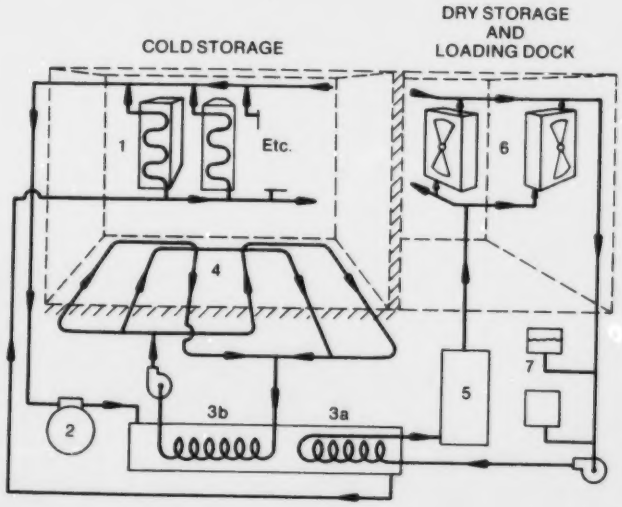
Plastic strip curtains were added at the freezer door openings to reduce moisture and warm air inflow. Air-inflated door seals were installed around truck doors to reduce the entry of cold air to heated areas.

Westco retained Fleming Pedlar Ltd. of Winnipeg to design and install the heat recovery system. The refrigeration system uses two rotary screw, electronically controlled compressor packages, with discharge temperatures typically at 46°C (115°F). They are rated at 150 hp and 200 hp. The manufacturer, FES of York, Pennsylvania, also supplied the liquid ammonia recirculating package and the evaporative condenser.

The schematic diagram provides an illustration of the heat recovery system. Heat is reclaimed from the hot, compressed ammonia refrigerant by transfer, through an ammonia-to-water heat exchanger, to a recirculating hot water heating system. The hot water is pumped through a loop connected to thermostatically controlled ITT-Grinnell suspended unit heaters, which extract the heat for space heating in the loading dock and dry storage areas. The loop is completed by a return line to the heat exchanger, and makeup water is automatically supplied from a sandpoint well. A 180 kW electric stand-by boiler reheats the water when space heating is required and the refrigeration plant is not running.

A second heat exchanger also reclaims heat from hot ammonia to heat a glycol solution that is circulated year-round through plastic pipes installed under the freezer room floor insulation. This keeps the soil above freezing to prevent heaving of the floor. A pre-set thremostat installed in the subsoil controls the operation of the glycol pump, and a charge of hot glycol is maintained by continually passing ammonia through the exchanger.

In warm weather, excess heat is automatically discharged through an outside evaporative condenser.



1. Evaporative coolers in freezer and cold rooms
2. Ammonia refrigerant compressors
3 a). Ammonia-to-water heat exchanger
   b). Ammonia-to-glycol heat exchanger
4. Underfloor heating (glycol solution)
5. Stand-by electric boiler
6. Hot water unit heaters
7. Expansion and water treatment tanks

Schematic diagram of the Westco heat recovery systems

Slow-moving fans, with variable speed controls, are installed at a high level throughout the heated areas of the building to prevent heat stratification.

The office has a separate heating/cooling system with a combination 13 kW heating and 5 ton cooling rooftop unit and supplementary baseboard heating.

The following improvements were made during the early stages of operations:

- The stand-by boiler is interlocked with the refrigerant compressors to ensure its operation only when the compressors are not in use.
- The ammonia recirculating pumps are interlocked with the compressors to stop them when the compressors are off.
- The evaporator fan motors in the freezer are interlocked with the thermostats on the solenoid valves, in order to stop the fans when the valves are closed.
- Two extra, thermostatically controlled, fans are installed in the mechanical room. One continuously exhausts heat into the loading dock in winter; the other exhausts heat outside in summer. They are interlocked with an ammonia sensor so that if ammonia is detected, it is vented outside.

Economic Analysis:

The estimated costs of the heating system and extra insulation in this new facility were as follows —

Energy Recovery System:

• Loading dock and storage heating	$ 50,990
• Subfloor heating	39,075
• Electrical (estimated)	9,935
Subtotal	100,000
• Less estimated cost of conventional system	(47,000)
Additional Cost	$ 53,000

The *total* additional costs (i.e., over and above the cost of more conventional approaches) are summarized as follows —

• Additional cost of energy recovery system	$ 53,000
• Additional roof insulation from RSI 3.5 to RSI 5.3	15,375
• Additional wall insulation from RSI 2.0 to RSI 3.5	5,200
• Premium for Coldstream panel wall system	34,725
Total Additional Cost of Measures	$108,300

A comparison of the energy costs for cooling of the old facility and the new facility:

- Old Facility — $1.589/m^3 ($0.045/ft^3)
  — $45,233 per year
- New Facility — $0.376/m^3 ($0.0106/ft^3)
  — $48,760 per year for 4 times more volume

Availability:

The energy recovery demonstration system was designed and installed by Fleming Pedlar Ltd., of Winnipeg,a wholesale contractor for plumbing, heating and air conditioning. Coldstream Products of Canada Ltd., Winnipeg, provided Westco with special urethane sandwich panels for additional wall insulation in the cold storage rooms.

The technology and equipment is available through contractors, suppliers and engineering consultants in major centres throughout Canada.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Energy Information Centre
  Manitoba Energy and Mines
  117-234 Donald Street
  Winnipeg, Manitoba
  R3C 1M8
  (204) 945-4154

Information on the demonstration project is also available from the suppliers:

- Fleming Pedlar Ltd.
  (re: ENEROPTIONS)
  565 Munroe Ave.
  Winnipeg, Manitoba
  R2K 1H7
  (204) 667-7863
- Coldstream Products of Canada Ltd.
  (re: ENEROPTIONS)
  1885 Sargent
  Winnipeg, Manitoba
  R3H 0E2
  (204) 669-1201

Flax Shives as a Fuel Supplement in a Cement Kiln

GENSTAR CEMENT LIMITED — WINNIPEG, MANITOBA

Technology:
Agricultural waste large-scale direct combustion

Demonstration Project Manager:
Process Superintendent
Genstar Cement Ltd.
P.O. Box 249, Station C
Winnipeg, Manitoba
R3M 0X0

Location:
Winnipeg, Manitoba

Annual Savings: $300,000-$500,000

Payback Period: 1-2 years

Applicable to:
Users of large quantities of fuel in close proximity to a concentrated supply of agricultural waste:

- Lime/cement kilns
- Non-metallic-ceramic industry-structural clay products (brick and tile), plaster refractory
- Drying and seasoning of lumber

Description:
Genstar Cement is burning as much as 45 tonnes (50 tons)/day of flax waste to displace natural gas in its Winnipeg plant. After a series of in-plant tests, Genstar Cement has demonstrated the viability of using flax shives as a cement kiln fuel supplement. Following the success of these tests, a full scale production system to burn flax shives was implemented. Flax shives are a waste product remaining after fibres are removed from flax straw for the manufacture of linen paper. Due to its excellent pricing structure and availability, the use of flax shives as a fuel is economically attractive.

Benefits:

- It is estimated that the use of flax shives as a fuel supplement saves 20-30% of the annual natural gas consumed. This was reflected as an energy benefit of 1.5×10^8MJ/year (or 1.42×10^5 MBtu/year).
- When piled correctly, the outer layers of a shives stockpile form a water-resistant cover. This permits outside storage — a low cost option.

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Performance:

- The demonstration proved the technical and economic feasibility of burning large quantities of agricultural waste as a cement kiln fuel supplement.
- For an estimated capital cost of $500,000 for the full scale unit, the energy savings are in the order of $3,000 to $5,000 per day of operation. This figure is based on flax shive costs of $0.001/MJ ($1.055/MBtu) compared to natural gas costs of $0.0045/MJ ($4.747/MBtu). This yields a payback period of one to two years.
- Since the flax shives supply is seasonal, it is necessary to stockpile a year's supply of this supplementary fuel. It must be piled correctly to shed water and remain dry enough for burning and also to avoid spontaneous combustion. This involves ensuring that the stockpile is not compacted during stockpiling.
- Flax shives are difficult to handle. They generate dust when tumbled, and they tend to bridge feed hoppers and to jam conveyors. This problem was overcome by closely monitoring the feed system.
- Agricultural equipment was used to feed the flax shives during both the test burns and in the first production system. Problems have been encountered with this equipment as it is very light for this industrial application. Heavy industrial feed equipment, now installed, is superior but more costly.

Technical Details:

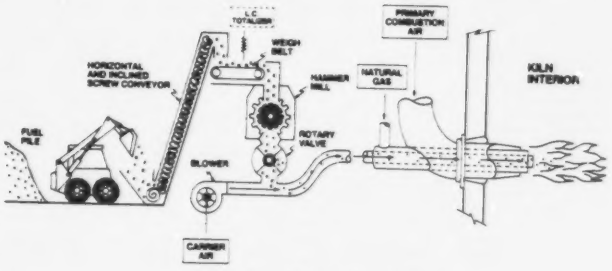
As shown in the illustration, flax shives from a stockpile are fed into a live bottom hopper and an inclined screw conveyor. The shives are elevated to a silo equipped with a controlled weigh feeder or reclaimer.

The feed material continues through a hammer mill to a blow-through type rotary valve with a drop-out chamber and venturi to assist the entry of the material into a pressurized feed pipe.

A blower pressurizes the feed line to the kiln burner and provides carrier air to suspend the shives particles. They are blown into the combustion chamber to which natural gas is also fed to ensure the required temperature.

Energy saving using the fuel supplement is estimated to be $3,000 to $5,000 per day of operation.

Dust control equipment was installed to comply with federal regulations and to recycle waste fuel.



Solid Fuel Feed System

The shives were obtained from a local processor and were stored on site. The shives maintained moisture contents of 8% to 10% in open storage without incidence of spontaneous combustion.

Economic Analysis:

The demonstration phase of this project involved a number of test burns using different fuel supplements. Based on the favourable results of the flax shives test burn, Genstar implemented a shives burning system without government assistance.

Detailed performance data and cost data of the production system are not available.

Genstar does report they are extremely pleased with the savings they are attaining. The economics proved to be as attractive as indicated during the tests.

Availability:

The demonstration unit was assembled and installed by Genstar Cement Ltd., from available equipment.

The technology, equipment suppliers and contractors are readily available throughout major centres in Canada.

Further Information:

Further information and a copy of the final technical report on the pilot test burns are available from:

- ENEROPTIONS
  Energy Information Centre
  Manitoba Energy and Mines
  117-234 Donald Street
  Winnipeg, Manitoba
  R3C 1M8
  (204) 945-4154

Retrofit of Schools for Energy Efficiency

MANITOBA

Technology:
Architectural, mechanical and electrical retrofit of 20 Manitoba schools for energy efficiency

Demonstration Project Manager:
Winnipeg: Mr. E. Card
W.L. Wardrop and Assoc. Ltd.
Rural: Mr. B. Sloane
Underwood McLellan Ltd.
Northern: Mr. Tom Wilson
Scouten, Mitchell, Sigurdson & Associates Ltd.

Location:
Urban, rural and northern sites in Manitoba

Annual Savings: Average of $10,400 or 25% of energy cost

Payback Period: Average of 2 years. Most Measures under 5 years

Applicable to:
Educational, commercial, institutional and municipal buildings

Description:
Twenty rural, northern, and Winnipeg schools were individually analyzed and selected to participate in a Manitoba/Canada energy efficiency retrofit program. ENERSCHOOL, as the program was known, tested and demonstrated various energy conservation techniques. Major retrofits, with an allocated budget of $47.30/m² ($4.39/ft²), were undertaken at two of the schools. The balance of the schools received minor retrofits, whose total cost was not to exceed $3.55/m² ($0.33/ft²). An energy analysis was completed for every school and measures were recommended that would give the most energy savings for the budget available. A procedures manual entitled "The Energy Conservation Process" was developed from the findings of the program to guide schools through cost-effective retrofits. These 20 school retrofits demonstrated that there is excellent potential for energy conservation in existing Manitoba schools and that significant savings can be achieved using measures with a payback period of less than 5 years.

Benefits:
- Demonstration of substantial savings which can be achieved simply through improved operation and maintenance procedures at low or, often, no cost.
- Employment in the renovation/retrofit/construction industry
- Sixteen other schools in the province are undertaking similar retrofit initiatives worth over $400,000 in capital costs
- Seminar manual developed for this project is widely applicable to other schools

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- Average annual estimated savings over all 20 schools were $10,400, ranging from approximately $1,700 to $44,000
- Relatively short payback makes borrowing attractive as a means of financing energy retrofit programs

Performance:

The consultants had no trouble finding significant energy savings which could be accomplished within the allocated budget. The estimated annual savings ranged from approximately $1,700 in one of the rural schools which had a minor retrofit to about $44,000 in one of the Winnipeg schools which was subject to a major retrofit. The average annual estimated savings over all 20 schools was $10,400; the major retrofits averaged savings of $32,100 and a payback of 2.5 years while the minor retrofits averaged paybacks of 1.8 years on retrofit costs of $8,000.

Payback periods for each of the measures range from 0.1 years to 12.4 years. The measures with the shortest payback are:

- Sealing ventilation dampers
- Weatherstripping and caulking of doors, windows and building openings
- Installation of automatic controls on mechanical systems to respond to building usage patterns
- Recalibration of thermostats
- Replacement of incandescent lighting with fluorescent lighting in corridors, locker rooms, etc., and with metal halide lighting in gymnasiums
- Installation of power factor correction where power factor is low.

Overall, the average payback period for retrofit work in the 20 schools was 2 years (not including consultant fees).

Technical Details:

Consultants undertook an inspection tour of the 20 schools. The schools included both one and two-storey buildings and ranged in size from 1,288 m^2 to 7,319 m^2 (13,864 ft^2 to 78,784 ft^2). Heating systems in the schools varied and included oil-fired systems, gas-fired systems, electric heating and a combination electricity and propane/oil burning system. An individual audit report was prepared for each school. A list of retrofit options was developed based on an analysis of the following items:

- Design and operating conditions
- Operating procedures and building use patterns
- Energy and cost savings
- Capital costs
- Simple paybacks
- Future building use

These measures addressed all areas of the school—the building envelope, the mechanical systems and the electrical systems. For each of these items, no-cost and low-cost measures and medium and high cost measures were indentified. Final selection of options for implementation was carried out by the project steering committee and the individual school boards. It should be noted that, in some instances, retrofit strategies implemented were not necessarily the ones with the best payback.

Members of all the school boards were invited to an energy conservation forum where they were introduced to energy conservation techniques and the retrofit process. The major implementation work was contracted out while other work was done in-house with guidance from consultants.

Techniques used included the following:

Building envelope:

- Sealing of all cracks in the building shell
- Weatherstripping of all entrances and vehicle doors
- Replacement of doors with insulated doors, where doors needed replacing
- Replacement of non-essential windows with insulated panels

Mechanical systems:

- Sealing exhaust and intake dampers
- Installation of automatic night temperature set-backs
- Recalibration of thermostats
- Switching off of all unnecessary mechanical systems during unoccupied periods
- Use of manual reset timers for air handling units and exhaust fans in intermittently occupied areas
- Installation of an automatic reset device for water boiler temperature relative to outdoor temperature

Electrical systems:

- Correction of power factor for all electrical services
- Modification to lighting including both switching off of lights and replacement of incandescent lights with more energy efficient lights.

Economic Analysis:

- Actual costs ranged from a low of $3,000 to a high of $88,000 and averaged $14,600 for a minor and $81,700 for a major retrofit
- Energy cost savings ranged from $1,700 to $43,800 and averaged $10,400 for all schools, $8,015 for those which had minor retrofits and $32,100 for the two with major retrofits
- Overall payback periods for the 20 schools averaged 2 years.

Availability:

Consultants qualified to perform the necessary audit and evaluation and to supervise the retrofit work are located across the country.

Further Information:

The ENERSCHOOL retrofit procedures manual and final technical report on the retrofit of the 20 schools is available from:

- ENEROPTIONS
  Energy Information Centre
  Manitoba Energy and Mines
  117-234 Donald Street
  Winnipeg, Manitoba
  R3C 1M8
  (204) 945-4154

Further information is also available from the demonstration project managers:

- Winnipeg: Mr. E. Card
  (re: ENEROPTIONS)
  W.L. Wardrop &
  Associates Ltd.
  77 Main Street
  Winnipeg, Manitoba
  R3C 3H1
  (204) 956-0980

- Rural: Mr. B. Sloane
  (re: ENEROPTIONS)
  Underwood McLellan Ltd.
  1479 Buffalo Place
  Winnipeg, Manitoba
  R3T 1L7
  (204) 284-0850

- Northern: Mr. Tom Wilson
  (re: ENEROPTIONS)
  Scouten, Mitchell,
  Sigurdson & Assoc. Ltd.
  300-297 Smith Street
  Winnipeg, Manitoba
  R3C 1L3
  (204) 942-3111

Remote Computerized Energy Management

ROLLING RIVER SCHOOL DIVISION — MANITOBA

Technology:
Multi-building energy management system using a central computer

Demonstration Project Manager:
Mr. B. Wilman
Rolling River School Div. #39
P.O. Box 1170
Minnedosa, Manitoba
R0J 1E0
(204) 867-2754

Location:
West central Manitoba

Annual Savings: $40,000 for 3 schools (40% of Total Costs)

Payback Period: 2.4 years

Applicable to:
Schools, institutions, or other groups of buildings which can be controlled by a single computer

Description:
The Rolling River School Division installed a remote computer energy management system in four of its schools and achieved savings averaging 40% of energy costs in the first year of operation. The energy management system uses a central computer at the Division headquarters in Minnedosa to control heating, ventilating and air conditioning (HVAC) at each school. Communication of data and control signals between the central control and the remote processing units at each school is through leased telephone lines. The energy-related control techniques include start/stop for unoccupied periods, optimized duty cycle and electrical demand control. Thus, using one computer, the School Division is able to control energy use in 4 or more remote schools.

Benefits:
- Control system offers large potential for achieving savings in energy and maintenance costs,
- Centralized system is more cost-effective than stand-alone systems for each building,
- Energy cost savings at individual schools of up to 65% have been achieved,
- Systems are flexible and can be easily adapted to other control and monitoring tasks.

Performance:
- The demonstration proved the technical and economic feasibility of controlling HVAC through a remote, centralized computer energy management system,
- Data transmission problems using the dedicated phone lines resulted in problems in one school, Erickson Collegiate; not being "on line" in the monitoring period,
- Energy savings achieved in 1983/84 with the system in the other 3 schools were as follows:

Tanners Crossing	867,127 kWh
Minnedosa Collegiate	493,520 kWh
Rivers Collegiate	888,943 kWh

- As a result of this project, 3 other school divisions (Interlake, St. Boniface, and Swan River) have established computer energy control systems and 20 additional school divisions in southwestern and southeastern Manitoba have initiated requests for similar systems.

ENEROPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENEROPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Technical Details:

The Rolling River Division school buildings are centrally administered from Minnedosa, Manitoba. The Division installed a Johnson Controls JC/85/10 Energy Management System with a central processor located at Division headquarters to control HVAC in 4 school buildings: Tanners Crossing (5,728 m^2 or 61,660 ft^2), Minnedosa Collegiate (3,888 m^2 or 41,852 ft^2), Rivers Collegiate (3,420 m^2 or 36,821 ft^2), and Erickson Collegiate (2,492 m^2 or 26, 829 ft^2).

Process

The central processor unit (CPU) makes control and energy optimization decisions based on internal programming (time scheduling, set and alarm points, and control algorithm). The CPU responds to information received from each school's Field Processor Unit (FPU), which receives and translates signals from sensors located throughout the school. A hard copy of CPU input and output is recorded on a printer.

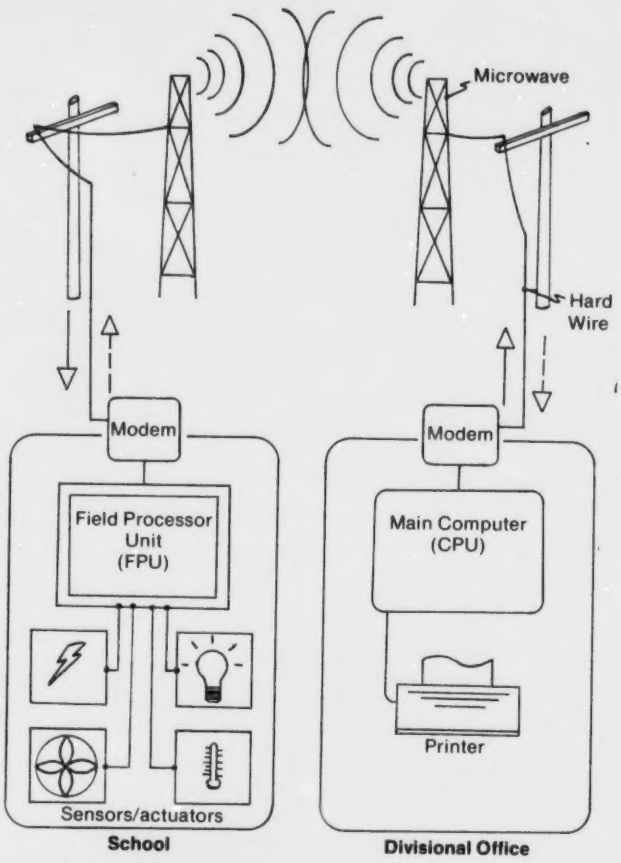
The CPU tests the information it receives against its program and decides what, if any, control action is needed. When action is required, control information is sent back to the appropriate school. The FPU passes the information to the proper actuator module which implements the required action via pneumatic and/or electric control mechanisms.

The CPU and the FPUs communicate using leased hard wire lines and microwave links.

Energy Management Measures

As an example, the energy management control measures that have been implemented at Tanners Crossing are listed below.

- Programmed start/stop matching equipment operation with occupancy schedule,
- Optimum start/stop for each air handling system,
- Night set-back of space temperatures,
- Temperature reset which makes reference to outside air temperature,
- Ventilation optimization,
- Electrical demand limiting to avoid portions of demand-related costs.



Data acquisition/control signal transmission pathway Rolling River school division

Economic Analysis:

Capital Cost: $96,460

Savings (by school)*:

Tanners Crossing	867,127 kWh** (33%) or $14,000
Minnedosa Collegiate	493,520 kWh** (29%) or $8,000
Rivers Collegiate	888,943 kWh** (65%) or $18,000
Erickson Collegiate	system not operating due to data transmission difficulties

Total Savings: 2,249,590 kWh (40%) or $40,000

* includes both electrical power and heating
** heating adjusted for degee days

Payback Period: $\frac{\$96,460}{\$40,000/yr} = 2.4$ years

Note: Erickson Collegiate is not included in this summary of savings. When the data transmission problems are resolved, the payback may be less than two years.

Availability:

This computerized energy management system was purchased from:

Johnson Controls Ltd.
600 Moray Street
Winnipeg, Manitoba
R3J 3V9
(204) 885-9360

Similar systems are available from companies across Canada.

Further Information:

Further information and a copy of the final report are available from:

- ENEROPTIONS
  Energy Information Centre
  Manitoba Energy and Mines
  117-234 Donald Street
  Winnipeg, Manitoba
  R3C 1M9
  (204) 945-4154

- Mr. B. Wilman
  (re: ENEROPTIONS)
  Rolling River School Div. #39
  P.O. Box 1170
  Minnedosa, Manitoba
  R0J 1E0
  (204) 867-2754

Two Town Retrofit

PINAWA AND STONEWALL, MANITOBA

Technology:
- Energy audits of buildings
- Diagnostic clinics for vehicles
- Retrofits of residences, municipal facilities and other buildings
- Monitoring of energy use

Demonstration Project Manager:
Gary Proskiw
UNIES Ltd.
1666 Dublin Avenue
Winnipeg, Manitoba
R3H 0H1

Location:
Pinawa and Stonewall, Manitoba

Annual Savings:
- 7% to 10% of annual energy use (exclusive of savings in transportation)
- Approximately $170,000 per year in the two towns

Payback Period: N/A

Applicable to:
- Small municipalities
- Neighbourhoods or districts in urban areas
- Energy conservation specialists reviewing methods for stimulating community involvement

Description:
Detailed energy audits were performed on more than half the buildings in the towns of Pinawa and Stonewall, Manitoba, each with populations just over 2,000, to demonstrate the potential of community energy conservation in the residential, municipal, industrial, commercial, institutional and transportation sectors. To encourage participation and a sense of community involvement, an energy conservation competition was staged between the two towns. This project demonstrates the level of conservation activity which can be implemented after home and building owners are given detailed instructions of what can or should be done.

- In the residential sector, an audit delivery system was established using local people hired and trained specifically for this purpose. These trained auditors performed energy audits on 50% of the housing stock in the two towns.
- In the municipal sector, five municipal facilities in each town were audited. Each municipality undertook at least one major conservation retrofit.
- In the transportation sector, fuel economy diagnostic clinics were set up in which 878 vehicles had their engine performance evaluated, engine timing and air/fuel mixture adjusted where necessary and their tire pressure checked.
- In the industrial/commercial/institutional sector, energy audits were performed on 42 buildings using the Manitoba Energy and Mines energy bus (part of the Canada Energy Audit Program).

A Statistical Base Module was created to monitor the achievements of each sector and to administer the competition-related aspects of the project.

Identifiable reductions in energy consumption were obtained in all end-use sectors through an intensive conservation program. While the results in each sector are important, this case study emphasizes the method and results from the residential sector.

Benefits:
- Reductions of energy use and energy expenditures in all sectors in each community
- 24 local jobs created during the course of the project
- Training of auditors who can continue to use their skills in future applications
- Much greater awareness of energy conservation opportunities and priorities among homeowners, building operators, municipal boards and vehicle owners.

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Performance (Residential Sector):

A free energy audit service was made available to all homeowners in the two towns. To meet the anticipated demand, 24 people were hired and trained as residential energy auditors and dispatchers in a 3½ week instruction course. Residential energy audits were then carried out over six months during which 345 houses were audited in Pinawa and 296 in Stonewall (roughly half the housing stock in each town).

Two technical seminars were held in each town to provide further information to homeowners. A small number of major residential retrofits were performed as demonstrations in each town (two in Pinawa and four in Stonewall) which resulted in an estimated 30% reduction in annual energy use.

This project offered several insights into what the average homeowner desired from an energy audit.

- Homeowners indicated that the qualitative rather than quantitative recommendations were the most valuable benefits from the homeowners' perspective. The ability of the audit to identify "which" measures to undertake, "what" their priority should be, "how" they should be carried out, etc., were the most important. The rigorous analytical treatment which produced estimates of energy savings, payback periods, etc., although contributing to the qualitative results, was of less interest to most homeowners.
- One of the greatest benefits of the audit was advising homeowners what NOT to do rather than what to do. Despite the high visibility of energy conservation and extensive public education programs, homeowners often displayed a very poor understanding of the most cost-effective ways to save energy. People were generally surprised to learn of the no/low-cost savings that were possible. They were also surprised to learn that such measures as window retrofits were not cost-effective. On the other hand, cost-effective opportunities to save energy, such as upgrading insulation levels of poorly insulated components, air leakage sealing and replacing older heating systems with more efficient units, were often overlooked by the homeowner.
- A critical requirement for a successful audit was found to be the need for extensive interaction between the auditor and the homeowner. This was required both to transmit advice and to convince the homeowner of the benefits of implementing the recommendations.

Performance (Other Sectors):

Muncipal Sector

Energy audits of five municipal facilities were performed in each town. Based on the audit results, two facilities in each town were selected to receive retrofits. The retrofits showed that the audits accurately predicted the anticipated savings from different energy conservation measures. Thus, the audits also proved useful in indicating priorities for investment and encouraging implementation of conservation measures. The most commonly recommended conservation measures were modifications to maintenance and operating procedures, night setbacks of thermostats, and reduction of air infiltration. The highest proportionate savings in any sector were realized within this sector as building operators and municipal councils reacted quickly to suggested improvements.

Transportation Sector

Fuel economy diagnostic clinics were held in each town. A total of 453 vehicles were processed in Pinawa and 425 in Stonewall. Each had its engine performance determined using a Sun Micro II analyzer. Minor adjustments to the engine timing and air/fuel mixture were made along with any necessary adjustments to tire pressure. These free clinics were peformed by local garages under contract to the project. The clinics were widely and enthusiastically used by residents and helped to promote the rest of the program. Unfortunately, monitoring was not possible for this sector.

Industrial/Commercial/Institutional Sector

Energy audits were made available to all buildings in this sector using the Manitoba Energy and Mines energy bus. This service delivers an on-site computer analysis of energy savings and recommends conservation measures. During this period, the energy bus audited 12 out of the 16 eligible buildings in Pinawa and 30 out of the 90 eligible in Stonewall. Recommended conservation measures were similar to those for the municipal sector but also included, in smaller buildings, additional insulation and tuning of the heating system and, in larger buildings, modification to ventilation controls, power factor correction, delamping and computer-operated control systems. Implementation was uneven in this sector and apparently depended not only on relative but also on absolute savings. In addition, operators of larger buildings tended to be more involved than did those of smaller buildings.

Statistical Base Module

This module estimated the effectiveness of the conservation measures in each sector and administered the competition between the two towns. Statistical data on the towns was collected and combined with estimates of energy use for each sector to predict pre- and post-project energy consumption. Estimates of the energy savings were then calculated. This module proved difficult to implement because energy data sources were poor. The competition itself produced some unexpected results with some areas (e.g., activities with school children) receiving a stronger response than anticipated and others (e.g., activities with the local business community) receiving a weaker response.

Technical Details (Residential Sector):

Four main activities dominated the work in the residential sector. Each is described below.

Development of Energy Audit Procedures

Since the residential energy audits were delivered by previously untrained staff, a series of audit procedures were developed to define the scope, objectives and methods by which audits were to be performed. These procedures were designed to describe all the major components of the audit from initial homeowner contact to presentation of final results.

Auditor Selection and Hiring:

Auditor selection and hiring were based on technical skills, communication skills, initiative and the overall impression of the written application and personal inteview. Townspeople were given preference for the positions in an effort to encourage local interest in the project. In the end, 24 individuals with varying backgrounds were chosen for the audit staff positions.

Residential Energy Auditor's Training Course

To train the staff members in their roles as energy auditors, a 3 ½ week training course was conducted. By the end of the course, staff were expected to be able to assess the potential for energy conservation within the house, priorize these opportunities in terms of their relative payback periods, and provide the homeowner with advice on how best to implement the recommendations. It was made clear to the students that they were not being trained as building inspectors, service people or assessors. The training curriculum was based on courses developed by Canada Mortgage and Housing Corporation.

Audit Delivery

Formal delivery of residential energy audits. Each audit consisted of five major steps:

1. Scheduling
   Audit scheduling involved maintaining a master schedule on the activities of each audit team and contacting each homeowner to determine an acceptable time for the audit.
2. House examination
   House visits were performed by a team of two auditors. A brief explanation of what the audit would include, which areas of the house would be examined, approximately how long the audit would take, and when the results would be presented, was given to each homeowner. Measurements

Residential energy auditor's training course schedule
Week 1

Monday	Tuesday	Wednesday	Thursday	Friday
Introduction — introduction to Town Energy Audit Match project — course intent, goals objectives and methods	Heating Systems — module IV course I — alternate systems, wind, solar, heat exchangers	Site Visit (4 rotating groups) — bungalow	Presentation of Site Assessment — student presentations	Review Calculator Exercises
The Assessment of Existing Conditions — module 1 course 3 — inspections	Heating — systems — wood heat — safe heating systems	Site Visit — 1½ story wood frame	Calculator and Math Exercises	Basic Building Physics — module II course 3 — air change — heat balance Basic Building Physics — simplified calculations procedures
Lunch — 1.5 Hrs.	**Lunch — 1 Hr.**	**Lunch — 1 Hr.**	**Lunch — 1 Hr.**	**Lunch — 1 Hr.**
The Building Structure — module II course I — systems, problems, inspections	The Electrical System — module V course I — service entrance, distribution, fixtures, inspections	Site Visit — split level	Metric Review	Exercises and Review of Calculation Procedures
The Plumbing System — module III, course I — supply, drainage, venting, fixtures, inspections	The Building Envelope — module VI course I — principles, components, problems, inspections	Site Visit — UFFI house	Basic Building Physics — module II course 3 — conduction heat loss Assign Calculator and Math Exercises	Basic Building Physics — airtightness, ventilation, air quality — human comfort — passive solar — retrofits and building operations
	Site Visit Preparation — objectives and goals	Course Review and Assessment		Course Review and Assessment
Evening	**Evening**	**Evening**	**Evening**	**Evening**
		Write Site Assessment — individual reports on 1½ storey house	Exercises — complete exercises at home	

were made of air and hot water temperature, and relative humidity. Smoke pencil examinations were completed for air leakage sources, where possible. No blower door airtightness tests, furnace efficiency tests, infrared scans or other measurements were performed. Dimensional data on the house and a measurement or estimate of the types and amounts of insulation present in each component were also obtained. After examining the house, the homeowners were asked to identify their interests and concerns with respect to energy conservation. After these steps were completed, the auditors returned to the office to perform the analysis.

3. Analysis
   The objective of the house analysis was to identify the most reasonable cost-effective conservation measures and to estimate their corresponding energy and dollar savings.
4. Report Preparation
   Using the results of the analysis, the auditors completed a report, which summarized the recommendations into three categories — no-cost, low-cost and cost-effective measures. An individual analysis of the anticipated energy and dollar savings and the simple payback period was performed for each recommendation which required significant cash outlays to implement but were judged to have reasonable paybacks. Safety or maintenance concerns were also commented upon where appropriate.
5. Report Presentation
   Presentation of the audit report to the homeowners was performed by an individual auditor who reviewed the recommendations with the homeowners, discussed their significance and noted any other concerns.

Economic Analysis:

Conventional economic analysis is not possible for this project because a large component of the cost involved training and monitoring and also because one of its goals was to identify low-cost ways to deliver energy conservation programs. However, because of the extended period of monitoring, it was possible to estimate annual energy savings, by sector, which on a percentage basis are as follows:

- Residential 4 to 5%
- Municipal 15 to 19%
- Industrial/commercial/institutional 1 to 10%*

*The wide range of results in this sector reflects differences in the industrial base of the two communities, with Pinawa having few but larger buildings, which meant that potential energy savings were greater and program delivery was easier than in Stonewall.

No comparable estimate was possible for the transportation sector as their individual vehicles could not be monitored; the consultants involved believe that savings of about 5% were obtained.

Availability:

The technology, equipment and engineering and consulting services are readily available throughout Canada to communities willing to undertake comparable programs.

Further Information:

For further information and a copy of the technical report, contact:

- ENEROPTIONS
  Energy Information Centre
  Manitoba Energy and Mines
  117-234 Donald Street
  Winnipeg, Manitoba
  R3C 1M8
  (204) 945-4154

Waste Heat Aquaculture

GRAND LAKE, NEW BRUNSWICK

Technology:
Use of low-grade heat from a thermal generating station, for aquaculture

Demonstration Project Manager:
Mr. W.C. Hooper
Fish and Wildlife Branch
Department of Natural Resources
Government of New Brunswick
P.O. Box 6000
Fredericton, New Brunswick
E3B 5H1
(506) 453-3755

Location:
Grand Lake, New Brunswick

Applicable To:
- Electrical utilities
- Fish culture (farms)
- Pulp and paper industry
- Oil refining

Description:
Waste heat in plant cooling water is helping fish and revenues grow in record time. Salmon smolts grow to stocking size and trout fingerlings to marketable size in 60 to 75% of the usual time due to this warm water, year-round approach at a New Brunswick fish culture complex.

Cooling water from the Grand Lake Thermal Generating Station is pumped to an adjacent aquaculture complex. The complex consists of relatively low cost large outdoor ponds and raceways and indoor hatching and rearing tanks.

Currently, efforts are on-going to accelerate fish production even further, using controlled daylight periods to determine spawning time and further elevations in water temperature—using heat recovered from the power plant condensate system — to accelerate growth.

This aquaculture project proved so successful it has been expanded into one of the largest fish culture facilities in Canada.

Benefits:
- Annual savings of between $150,000 and $750,000, based on raising 100,000 to 500,000 smolts per year, may be achieved by commercial operators.
- Large ponds for fish rearing are found to be superior to conventional circular and raceway pond designs. There is a lower cost of construction; $6.50/m^2 ($0.60/ft^2) compared to $37.10/m^2 ($3.40/ft^2).
- Stressful temperature variations are reduced in the large ponds. Feeding operations were simplified. Fish expend less energy in a pond compared to a stream environment thereby maximizing growth.

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Performance:

- Brook trout grew from the fingerling size of 91 g (3.2 oz) to the marketable size of 227 g (8 oz) in 90 days. Brook trout hatched in December grew to 15 cm (6 in) by May. This provides fish farmers with a technique to grow 454 g (1 lb) fish by the fall and makes them available for marketing throughout the winter without the expense of "boarding" the fingerlings.
- Atlantic salmon fingerlings grew from 5.2 g (0.18 oz) to a weight of 26.7 g (0.94 oz) in one year. Twenty per cent grew to smolt size in the same year. (Normally this takes two to three years.)
- During the first two years of operation, a number of important lessons were learned.
  - Only certified, disease-free fish should be reared; good fish husbandry should be practised at all times with pond cleaning occurring every three to four months.
  - The supersaturation of water with atmospheric gases caused gas bubble disease. This situation was easily and inexpensively controlled by installing baffle structures to degasify the water. This simple apparatus reduced the total dissolved gas level of inflow from 121% to below 103%. At this level the trout and salmon fingerlings did not have internal or external symptoms of gas bubble disease.
  - Chlorination of power plant condenser cooling water was avoided. Also, anti-fouling agents were not added to the cooling water used by the power plant.
  - Atlantic salmon fry should initiate feeding by late February and should attain a three gram size by June if they are to smoltify as yearlings.
  - Atlantic salmon smolts should be subject to at least four weeks of cool water, i.e., 9° C (48° F) conditions prior to release to the wild or delivery to sea pens.
  - Atlantic salmon smolts should not be subjected to a sudden temperature drop of more than 4° C (7° F); greater temperature reductions should be staged over a 24-hour period.
  - Summer rearing of salmon and trout fingerlings at a power plant facility is feasible if ground water or cool lake water supplies are available.
  - Special provision (an adjoining sump) should be made for removal of wastes.
  - Trout or salmon carrying capacity should not exceed 0.5 kg/litre/minute (5 lbs of fish/gallon/minute).

Technical Details:

Four fish rearing ponds were roughed out in an abandoned fly ash lagoon near the Grand Lake Thermal Generating Station. The two larger ponds are 60 m x 30 m x 2.1 m (200 ft x 100 ft x 7 ft) deep and the two smaller ponds are 43 m x 18.5 m (140 ft x 60 ft).

The sides and bottom are covered with 20 cm (8 in) of fly ash as a protective underlayer for a 30 mil 'Hypalon' membrane liner. The ponds have 2:1 side slopes and a 1:300 bottom slope for drainage and cleaning. Drain tiles are installed under the Hypalon liner.

Four inflow water degassification structures 3 m x 2.5 m x 1.8 m (10 ft x 8 ft x 6 ft) are constructed out of timber. Inflow water is directed from a head tank 2.4 m (8 ft) over a series of five offset baffle drip traps and through a wooden sluice to the pond.

Warm (12° C) condenser cooling water discharged from the plant is pumped into the ponds by two 30 kW (40 hp) vertical column pumps. Lake water is also pumped to the ponds via a 30 kW (40 hp) submersible pump. This water may be mixed with the warm water to produce the desired water temperature in the rearing ponds.

Four 15 cm (6 in) drains are installed at the outlet of the ponds. Wire mesh screens cover the ends of the pipe to prevent the escape of fish. Water drains by gravity from the ponds into Grand Lake.

Stocking began in October 1980 and the facility was officially opened in October 1981.

Annual fish production levels are 200,000 brook trout, 60,000 lake trout and 60,000 salmon smolts.

The fish are fed a custom diet prepared on site.

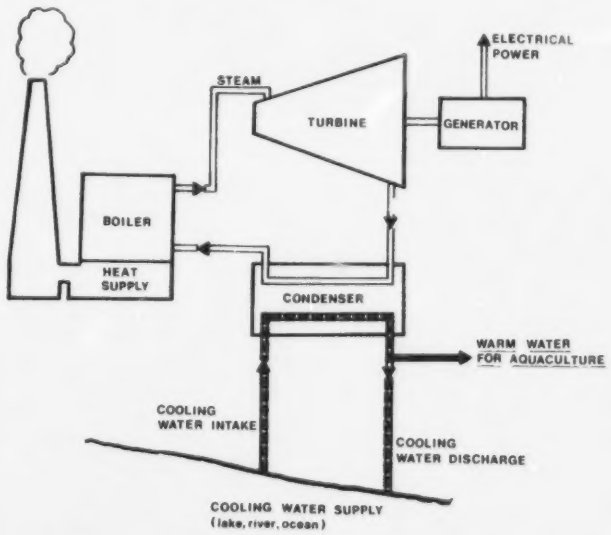
Fish are harvested by lowering the depth of the pond, crowding them into the corner with a sein net and then removing them with dip nets.

Close attention and monitoring by qualified staff is necessary to insure good health and rapid development of the fish.

Following harvesting, the ponds are drained, allowed to sun dry and then swept clean.

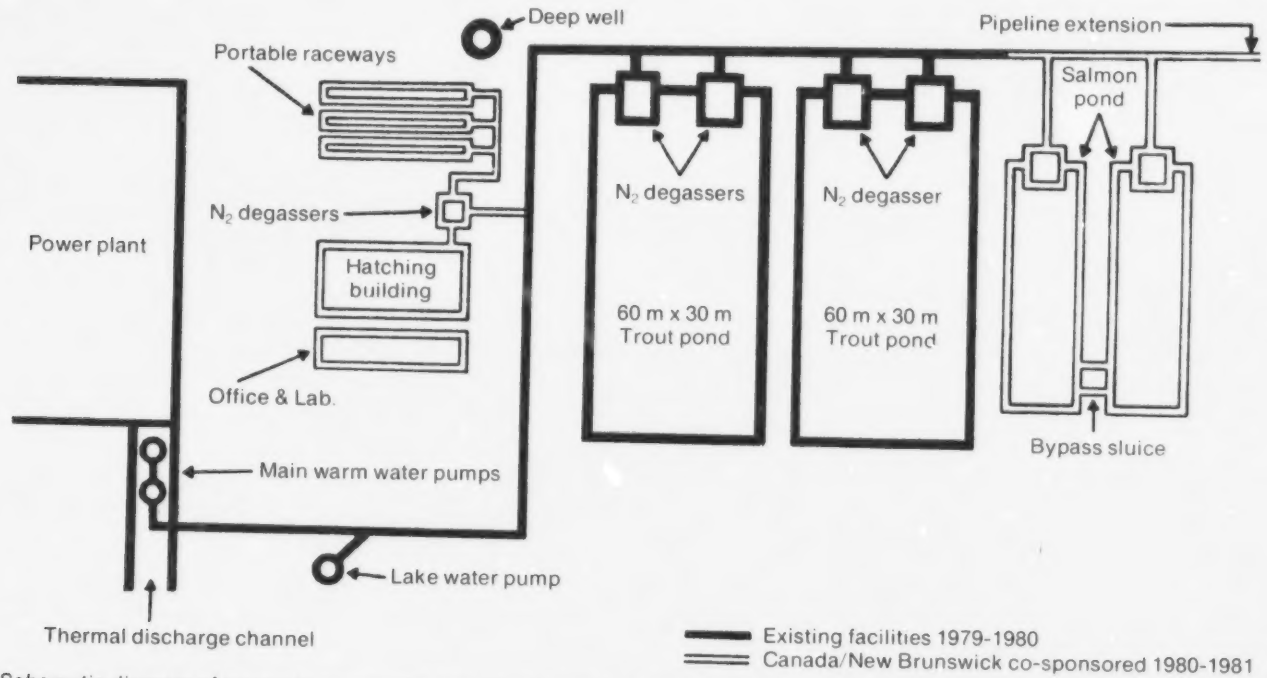
Under a subsequent phase, initiated in 1982, efforts are ongoing to produce marketable size trout and salmon smolt in 10 months from egg fertilization rather than in the 18 months achieved during the first phase.

A tank at a nearby hatchery has been light proofed and equipped with timer controlled lighting. Using photoperiod control, efforts are being made to stimulate spawning in July rather than October. The progeny can then develop in the warm summer water at the hatchery. In fall, the fish are transferred to 16° C (61° F) water at the Grand Lake facility where accelerated growth can continue during the winter.



Schematic diagram of power plant/cooling water interface

The 16° C (61° F) water is obtained by enriching the 12° C (54° F) condenser cooling water, described above, with heat recovered from the power plant's condensate system. Heat is recovered from the flash steam produced in the condensate collection tank and from the condensate itself using heat exchangers.



Schematic diagram of aquaculture complex and interface with power plant thermal discharge

Economic Analysis:

The total installed cost of the first phase of the aquaculture facility was $400,000. This is considerably less than that of a conventional facility of comparable capacity.

Full cost details on the second phase, which includes recovery of additional heat from the power plant condensate system, are not available as yet.

The economics of waste heat aquaculture are very attractive due to reduced capital costs and since a marketable product is produced in a much shorter time than required in a conventional unheated environment.

Complete cost details on this project are available from the demonstration project manager. The determination of the overall attractiveness of this technology in other settings would require a site feasibility study.

Availability:

The design, construction and operation of a waste heat aquaculture facility requires the services of both qualified biologists and engineering consultants.

Further Information:

Further information and copies of available reports on this demonstration project are available from:

- ENEROPTIONS
  Energy Secretariat
  Government of New Brunswick
  P.O. Box 6000
  Fredericton, New Brunswick
  E3B 5H1
  (506) 453-3897

- Mr. W.C. Hooper
  (re: ENEROPTIONS)
  Fish and Wildlife Branch
  Department of Natural Resources
  Government of New Brunswick
  P.O. Box 6000
  Fredericton, New Brunswick
  E3B 5H1
  (506) 453-3755

Reliable Bin-Feeder Design for Biomass Materials

B.C. RESEARCH—VANCOUVER, BRITISH COLUMBIA

Technology:
Storage and flow of biomass

Project Manager:
Nazmir Bundalli, P. Eng.
Senior Engineer
B.C. Research
3650 Wesbrook Mall
Vancouver, B.C.
V6S 2L2

Location:
Vancouver, B.C.

Savings:
Half or less of the capital cost and less than one-third the operating cost of conventional storage and recovery systems.

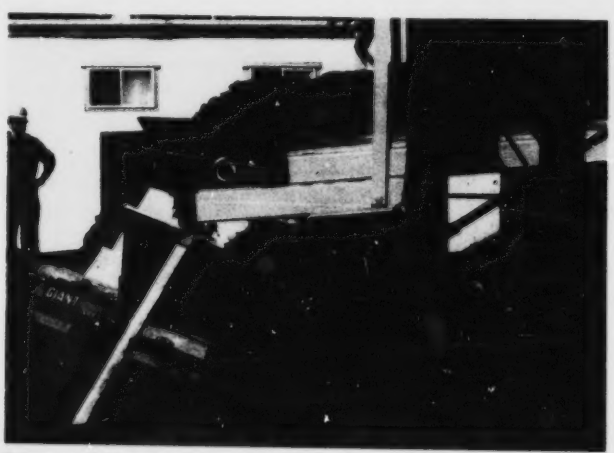
Additional savings from improved reliability.

Applicable to:
Industrial, commercial and institutional storage and recovery of: hog fuel, wood chips, sawdust, shavings and other forms of wood residues for fuel.

Description:
An improved bin-feeder design has been developed to eliminate flow stoppage, a major problem in the use of biomass residue fuels. The design utilizes a converging, mass flow hopper with outlet dimensions in the range 0.8 m (2.6 ft) to 1.5 m (5 ft), depending on the flow characteristics of the material to be stored as well as storage conditions.

The discharge feeder is designed to promote flow over the full length of the outlet slot and to reduce or eliminate stress build up and compaction of the material at the front vertical wall, a major cause of bridging.

Multiple screw, chain or belt feeders are used for slot lengths up to 8 m (26 ft). The 8 m limit on the length is necessary due to the difficulty in feeding uniformly over longer openings. A new discharge feeder currently being developed will not have this length limitation. The bin-feeder design allows reliable and uniform flow under gravity alone, without the need for flow promoting devices.



Energy efficient belt feeder.

Benefits:
- Eliminates stoppages in flow which are disruptive to production.
- Uniform, first-in-first-out flow results in consistent quality of feed to energy conversion or processing system.
- Converging hopper design reduces stress on the discharge feeder as well as simplifying its design and lowering its power requirements.
- A reliable and economical bin-feeder system is achieved.

This ENERGOPTIONS case study provides you with results of this successful project, assisted by the EMR Bioenergy Development Program (BDP). ENERGOPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories and The Yukon.

Performance:

The bin-feeder design principles have been demonstrated on an 80 m^3 (2,825 ft^3) capacity bin located at B.C. Research. The first series of tests were done without a discharge feeder in order to confirm the outlet dimensions and hopper slopes independently of the feeder performance.

- Hog fuel and wood chips were found to flow easily through a converging hopper with outlet dimensions that were very practical and much smaller than those commonly used.
- Flow was feasible even for the worst flowing hog fuels (e.g., stringy cedar bark) after prolonged periods of storage at rest.

Initial tests with a multiple screw discharge feeder ran into severe bridging problems which resulted from poor feeding. These problems were overcome by improving the flow through the full 5 m (16 ft) long slot. A major problem that had to be overcome was the lack of movement and compaction of material at the front vertical wall.

- Power requirements of the feeder decreased substantially with improved feeding.
- It was concluded that excessive power input at the feeder, if applied improperly, is a major cause of bridging.

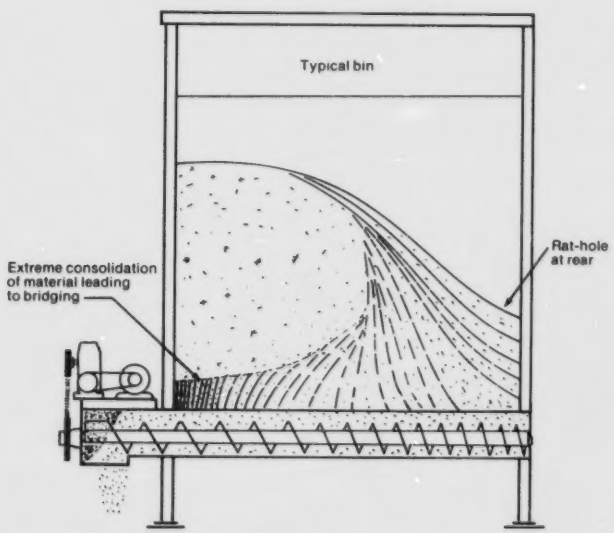
A simple belt feeder consisting of a smooth belt on a flat deck was subsequently operated with a 1.1 kW motor.

Technical Details:

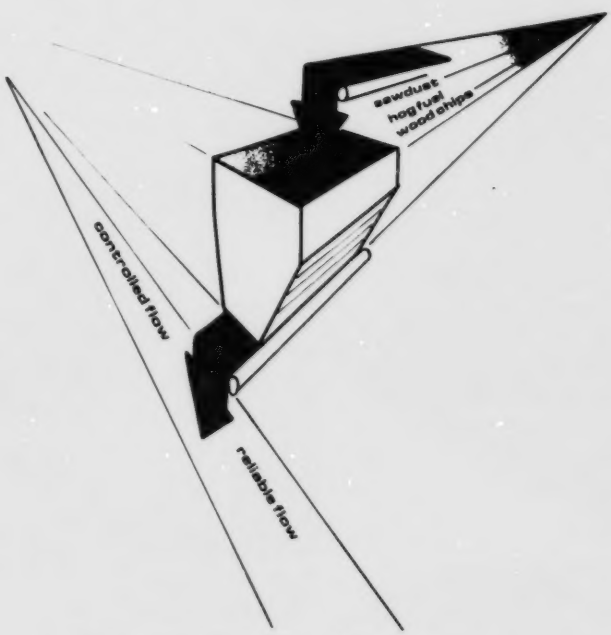
Extensive laboratory evaluations were carried out on specially constructed equipment during 1981/82.

- A major problem with biomass was found to be its enormous resistance to funnelling (or "flowing over itself"). Hopper design that relies on the material flowing through the centre core of the bin cannot work
- With a mass flow hopper design (characterized by smooth, steep hopper walls), flow under gravity alone was found to be feasible. Outlet dimensions predicted were quite practical and much smaller than those commonly used.
- Hopper slopes necessary for mass flow were found to be very steep and, hence, impractical for most situations with conventional bin wall materials (concrete and steel). Special lining materials were found to be necessary.
- High molecular weight polyethylene and glass-coated steel surfaces were found to have sufficiently low wall friction to allow reasonable hopper wall slopes.

The above laboratory findings were confirmed on an industrial size bin. The discharge feeder was found to be a key component and required considerable attention to assure uniform flow over the full opening.



Typical Discharge Feeder Problems



- *bin & feeder designed as an integral unit*
- *relies only on gravity for flow*
- *eliminates consolidation from poor hopper and/or feeder design*
- *substantial power savings*
- *design adaptable to capacity and plant layout*

Economic Analysis:

The following table compares two common bin feeder systems to a BC Research /UKAF unit of the same capacity, 25 units or 140 m^3 (5,000 ft^3).

	Bin Feeder System		
	Stoker	**Travelling Screw**	**BCR/UKAF**
Installed Cost of Bin	$ 70K	$ 80K	$110K
Discharge Feeder	$260K	$190K	$ 40K
Drive Motor, Controls And Wiring	$ 70K	$ 30K	$ 10K
Motors Required	4-60 hp 1-5 hp	1-60 hp 1-5 hp	1-25 hp
Total Installed	$400K	$300K	$160K
Annual Costs			
Power ($200/hp)	$ 25K	$ 13K	$ 5K
Maintenance (10% of feeder cost)	$ 26K	$ 19K	$ 4K
Total Annual O&M	$ 51K	$ 32K	$ 9K
Reliability	Poor	Fair	Good

Thus, the new B.C. Research/UKAF bin feeder design offers a more reliable installation at almost half the cost and less than one-third the operating cost of the closest alternative.

Availability:

The research was carried out by B.C. Research in Vancouver, British Columbia. UKAF Canada, a Vancouver-based company, provided considerable practical input. B.C. Research and UKAF can assist with evaluations and engineering for new bin-feeder systems or improvement of existing ones. A large pulp and paper company is presently making modifications using this design.

Further Information:

Further information and copies of technical reports are available from:

- ENEROPTIONS
  Bioenergy Development Program
  Renewable Energy Division
  Energy, Mines and Resources Canada
  580 Booth Street
  Ottawa, Ontario
  K1A 0E4
  (613) 995-9447

For information on application of the research, contact:

- B.C. Research
  3650 Wesbrook Mall
  Vancouver, B.C.
  V6S 2L2
  (604) 224-4331
  Attention: Mr. Nazmir Bundalli
  (re: ENEROPTIONS)
- UKAF Canada
  Division of Skeath Materials Handling Ltd.
  1250 Homer Street
  Vancouver, B.C.
  V6B 2Y5
  (604) 681-1847
  Attention: Mr. David Skeath
  (re: ENEROPTIONS)

Building Energy Management System

MUNICIPALITY OF SURREY — BRITISH COLUMBIA

Technology:
- Central computer control and monitoring of building functions
- Energy management system

Demonstration Project Manager:
Deputy Chief Inspector of Municipal Buildings
Municipal Hall
14245 — 56th Avenue
Surrey, B.C.
V3W 1J2

Location:
Surrey, British Columbia

Annual Savings: $38,620
8% of pre-demonstration costs

Payback Period: Average 3.2 years
(Range 1 to 20 years for individual buildings)

Applicable to:
Situations where widely-scattered buildings are operated by one administration, such as:
- Municipal buildings
- Government offices
- Institutions — universities, hospitals, schools
- Commercial and residential complexes
- Industrial complexes

Description:

Energy use in seven scattered municipal buildings in Surrey, B.C. is successfully monitored and controlled by a retrofitted, centrally located computer.

The Building Management System (BMS) consists of a central energy management mini-computer connected by leased telephone lines to a number of remote microprocessors.

The BMS regulates such building functions as heating, air conditioning, lighting and hot water requirements. The system was further expanded to monitor fire and building security.

Benefits:
- First year energy savings for the municipality's facilities were shown to be approximately 8% of its annual expenditure for gas and electricity, based on 1982 rates. Even with the extra cost of retrofitting, paybacks as low as 1.2 years were achieved.
- The centralized control concept enables key supervisory staff to monitor the performance of the individual buildings and the total system and to make any necessary control adjustments from a single location.
- The recorded performance data can be used to evaluate the systems and their components to detect changes in their efficiency or reveal a condition that might require maintenance or replacement.
- Comfort level improvements were noticeable by the reduction of complaints from users of the municipal pools and exercise areas.
- Reduced manpower and travelling expenses.
- Reduced system maintenance costs.
- The BMS can also centrally monitor fire, building security and other functions.

ENEROPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENEROPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Performance:

Following the installation of the BMS demonstration system, its advantages and satisfactory performance were confirmed by a year of operational monitoring.

- The total annual energy saving was $38,620. The annual saving was $21,823 on natural gas (based on $0.387 per billing unit of gas); and $16,797 on electricity (using $0.0359/kWh).
- Although alternative communication media are available for linking central processing units to field monitors (e.g. microwave and cable systems), leased telephone lines were chosen. There was an initial problem of incompatibility between the available lines and the BMS unit, but this was overcome. (The supplier of such systems should be required to establish the compatibility of his equipment with the chosen communication media).
- There were five different building types among the seven facilities monitored and controlled by the Surrey BMS installation. A thorough preliminary energy audit should be made of all facilities to determine the lowest cost system alternative, including BMS, for energy use reduction.
- A "user-friendly" software program is recommended for the most efficient operation of the BMS.
- Subject to the capacity of the central processing units, such systems are applicable to a broad range of public and private installations.

Technical Details:

The District of Surrey has paid up to $500,000 annually for heat and light in some 16 buildings. In 1981, the District submitted proposals to demonstrate the practicability of operating a computerized building energy management system (BMS) in these facilities.

A scaled-down program was designed to reflect available funding and the need to first demonstrate feasibility and system performance.

As illustrated in the schematic drawing, seven separate facilities - representing five different types of buildings - were selected for the demonstration, including:

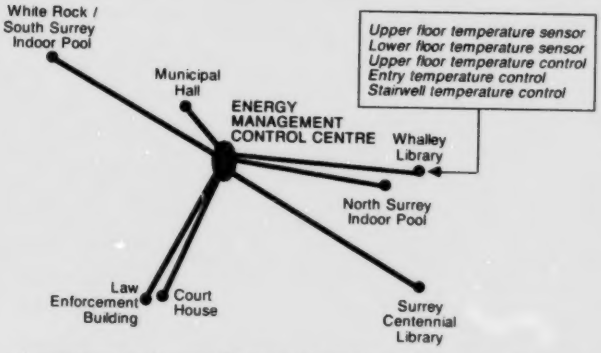
- 2 Libraries
- 2 Swimming pools
- Municipal office buildings
- Court house
- Law enforcement building

The BMS selected was a Johnson Control JC/85/10 energy management computer with four other components completing the system hardware.

The system was installed between April and September of 1982 and debugged during the following six months. Pre-installation energy performance data were accumulated between May 1, 1981 and April 1982, forming the "base year" data for comparison with the corresponding data recorded during the first operational year (September, 1982 to August, 1983).

The Central Processing Unit (CPU) is a microprocessor-based computer with 64 K (Kilobytes) of random access memory that monitors and controls energy consumption in selected buildings. It incorporates a CRT display monitor for immediate reference to all BMS activities. The CPU is centrally located at the building maintenance headquarters and is connected to a Field Processing Unit (FPU) in each of the seven buildings via leased B.C. Telephone lines.

The FPUs were hard-wired to all pieces of equipment in the buildings which were to be monitored and controlled. They collect information from Field Sensors installed at the selected control "points" in each building (e.g., light switches). Integral 1200 BAUD modems in the FPUs permit the transmission and receipt of such information back and forth between the CPU and the remote FPUs. The CPU processes the information it receives and individual software programs, in a disc drive attached to it, drive the CPU to respond to the information by sending appropriate signals back to the FPUs.



Locations of Surrey Energy Management System Components

Field Equipment Units (FEU) incorporate transducers that monitor the field sensors. The final component of system hardware is the Printer which produces hard copy records and a log of all energy management activities.

The Surrey BMS performs the following main functions:

- The CPU starts and stops various equipment at pre-determined times during each day of a calendar year.
- Through temperature-compensated duty cycling, individual fans operate to control temperature and maintain swimming pool humidity. Pool water heaters are also maintained within an optimum temperature range.
- The CPU maintains individual ventilation system air supply temperatures at optimum levels.
- An optimal stop/start feature permits the CPU to start or stop air handling systems either earlier or later in the day depending on the varying conditions in each building.
- The CPU can shed pre-selected loads at critical times of the day to limit peak energy demand charges.

The inclusion of the FPUs in the system, to control individual building operations and to store information in the event of power failures, proved valuable. Greater flexibility was provided for the CPU to maintain control over the operation of the field stations and to alert maintenance personnel regarding operating problems.

Following completion of the monitoring period, the control of the court house and law enforcement building was discontinued. Both of these buildings are used for extended periods during each 24 hours, thus limiting the potential for automated temperature and ventilation setback and lighting control. The payback periods on the equipment deployed was found to be in the range of 16 to 20 years.

Economic Analysis:

Project Capital Costs

Capital Cost (plus Installation Cost)	$120,170
Installation (incidentals)	2,830
Total Installed Cost:	$123,000

Annual Operating Cost Savings*

Electricity (467,883 kWh @ $0.0359/kWh)	$ 16,797
Natural Gas (56,390 Billing Units @ $0.387/BU	21,823
Total Annual Savings:	$ 38,620

*Maintenance costs not available

Simple Payback Period: 3.2 Years

Simple paybacks on individual buildings ranged from 1.2 years to 19.7 years.

Availability:

Building energy management systems are available from the major suppliers of control equipment. Some of these suppliers also provide innovative financing packages to assist customers in acquiring systems.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  100 West Pender Street
  Room 200
  Vancouver, B.C.
  V6B 1R8
  (604) 666-5810 or
  112-800-663-1280 (toll free in B.C.)

Information on this demonstration project is also available from the equipment supplier:

- Johnson Controls Ltd.
  (re: ENEROPTIONS)
  120 Bermondsey Road
  Toronto, Ontario
  M4A 1Z6
  (416) 757-2821

Modifications to Wood-Chip Boiler

MARITIME FOREST RANGER SCHOOL

Technology:
Automatic wood-chip heating system

Demonstration Project Manager:
Mr. George Walsh
Maritime Forest Ranger School
R.R. #5
Fredericton, New Brunswick
E3B 4X6

Location:
Fredericton, New Brunswick

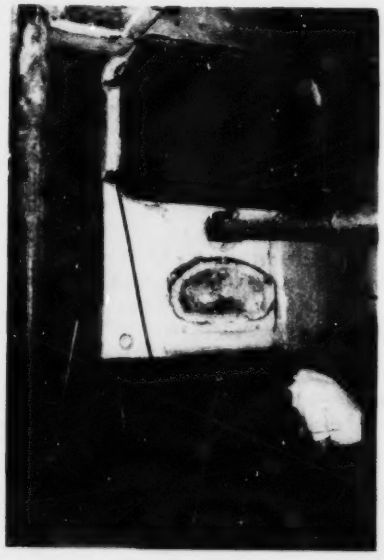
Annual Savings: $22,750
65% reduction in wood fuel costs

Payback Period: 1.4 years

Applicable to:
Institutional and commercial facilities located near forest processing industries.

Description:
The existing wood-chip boiler system at the Maritime Forest Ranger School was modified and updated to improve efficiency, reliability and safety and to expand the range of cull wood it could use. The School, located in Fredericton, New Brunswick, has utilized wood as its primary heating source since its construction in 1946. Fuel wood is harvested in conjunction with the forest management of the University of New Brunswick's woodlots.

The original system fired 1.2 m (4 ft) roundwood logs, but was awkward and labour-intensive. The present wood-chip heating system was installed in 1978. Operating experience gained from 1978 to 1980 indicated that modifications to the heating system would further improve the functional reliability and safety of the plant. It also became apparent that the installation of a chip screen would expand the range of usable cull wood and thereby reduce fuel costs. These changes were made in 1981/82.



Benefits:
The modifications to the wood-chip heating system have:

- expanded the range of cull wood to include low grade roundwood and mill slabs, resulting in a 65% or $22,750 annual saving in wood costs;
- reduced the total fuel cost per degree day by about 7% (with wood prices held constant and stand-by oil prices rising);
- significantly improved system reliability;
- reduced dependency on the oil-fired stand-by system;
- reduced fly ash emissions.

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Performance:

Each of the system modifications carried out under this demonstration have contributed to a significant increase in the overall reliability of the system. Improvements to the chip storage system have reduced chip bridging problems and the addition of the chip screen has allowed the chip handling system to operate for up to 2 months without blockage. This has virtually eliminated unscheduled interruptions.

The addition of the chip screen has also successfully broadened the range of usable cull wood. This means that the school's annual requirement of 700 cords of wood can now be supplied from a 50/50 mix of sawmill slabs @ $10/cord and low-grade cull roundwood @ $25/cord, instead of top-grade cull wood @ $50/cord. This represents an annual wood fuel savings of $22,750.

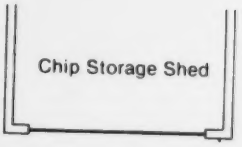
Technical Details:

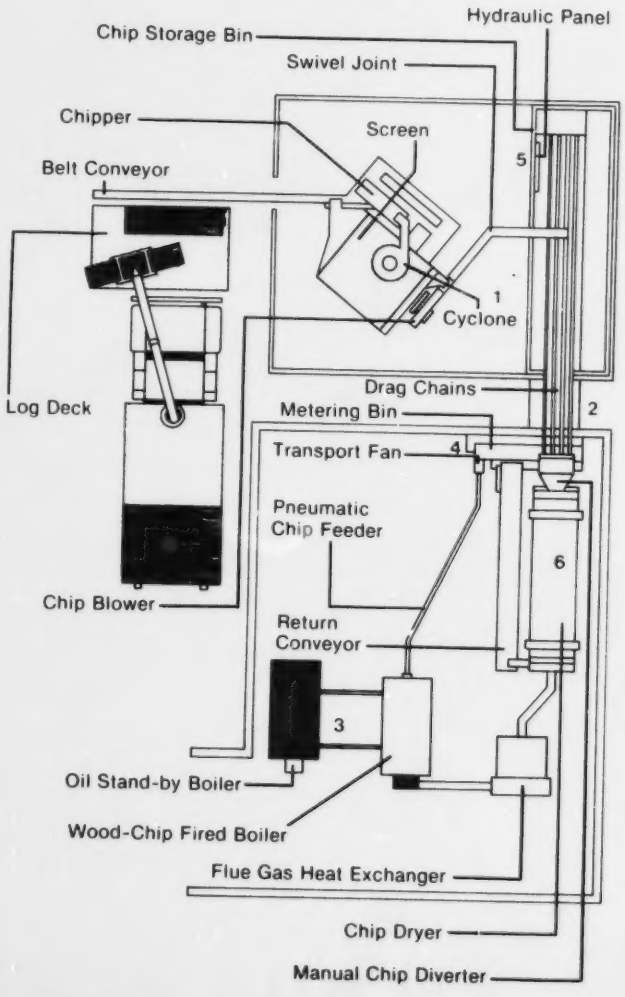
The schematic diagram of the wood-chip heating plant shows the six major modifications carried out within this demonstration. A brief description of each modification is presented below:

- Chip screen and blower — To eliminate feed system blockages resulting from cull wood splinters, a 1.8 m (6 ft) square oscillating chip screen was installed between the chipping and the storage bin. The cull wood is now fed through the chipper and exits into a cyclone located above the screen. The "accepts" are directed through a chute to a storage bin or to outside storage. The "rejects" are recycled through the chipper.
- Drag chains — Several flights of the storage bin drag chains were replaced to ensure continuous discharge. In addition, spacers and collars were added between each rear sprocket to prevent lateral movement and to eliminate previous misalignment problems. Finally, two chain rollers were added to support the return chain in order to reduce adjustments to chain tension.
- Hot water recirculation — A condensate recirculation system was installed to maintain the oil-fired stand-by boiler at operating temperature by using hot water from the wood-fired boiler.
- Second metering control — A second diaphram type, high-level switch was added to the chip storage bin for positive level control during periods when the chip dryer was in operation.
- Hinged bin wall — A hydraulically actuated panel on the bin wall, hinged at the top and swinging outward at the bottom, was installed to counteract previous chip bridging problems which occurred towards the rear of the bin.
- Chip dryer — A cylindrical insert was installed in the centre of the existing dryer to increase the area of chips in contact with the warm air from the stack gas heat exchanger. The insert is hollow and has 6 longitudinal fins equi-spaced about the circumference. It also has a series of holes between two adjacent fins which allow chips to enter the centre portion of the insert. The insert is attached to the outer dryer shell and rotates concentrically with the dryer.

In addition to the above major modifications, combustion air was reduced, draft gauges were installed, a new safety switch (operating on the principle of differential pressure) was installed for operation of the induced draft fan on the stack, and the chip feed hopper was modified slightly.

1 Installed chip screen and blower to eliminate chip feeding problems.
2 Modified drag chains to improve effectiveness.
3 Installed hot water recirculation system to eliminate stand-by system from cycling on oil.
4 Installed second metering bin levelling control to eliminate failures.
5 Installed hinged bin wall panel to eliminate chip bridging problem.
6 Modified chip dryer to improve efficiency.





Economic Analysis:

The modifications outlined above have collectively contributed to reduced fuel and maintenance costs as well as improved combustion efficiency. With the exception of the addition of the chip screen, the individual contributions of each modification have not been isolated. In the following economic analysis, the cost reductions resulting from the addition of the chip screen are assessed against the total project costs. If assessed against only the $15,607 cost of the chip screen, the simple payback period is about 8 months.

Project Costs

• Chip screen	$15,607
• All other modifications	$16,134
Total Equipment and Installation:	$31,741

Annual Wood Fuel Saving

• Previous cost 700 cords top grade wood @ $50		$35,000
• New cost 350 cords cull roundwood @ $25	$ 8,750	
350 cords slabs @ $10	3,500	
Total:	$12,250	$12,250
Annual Savings:		**$22,750**

Simple Payback Period: 1.4 years.

Availability:

The design, installation and monitoring of the system modifications were carried out by ADI Ltd., a New Brunswick engineering consulting firm specializing in wood burning systems. Similar services may be available in other locations across Canada.

Further Information:

A final report on this demonstration is available from:

- ENEROPTIONS
  Energy Secretariat
  Government of New Brunswick
  P.O. Box 6000
  Fredericton, New Brunswick
  E3B 5H1
  (506) 453-3897

Further information is also available from:

- Mr. George Walsh
  (re: ENEROPTIONS)
  Maritime Forest Ranger School
  R.R. #5
  Fredericton, New Brunswick
  E3B 4X6
  (506) 454-4363

Kort Nozzle for Fishing Trawler

Technology:
Ducted propulsion system

Demonstration Project Manager:
Herman Branch
Fisheries School
New Brunswick Department of Fisheries
Caraquet, New Brunswick
E0B 1K0

Location:
Caraquet, New Brunswick

Annual Savings: $12,730
20% of annual fuel costs

Payback Period: 1.8 years

Applicable to:
Technology is particularly applicable to new fishing boats. On older fishing vessels, it is most applicable to stern draggers.

Description:
The fishing vessel "Jean Colette" is now a more fuel-efficient and productive member of the New Brunswick shrimp fleet — thanks to the installation of a Kort nozzle.

In general, the shrimp fleet is the least fuel-efficient of the New Brunswick fishing fleets. Each vessel consumes between 132,000 and 150,000 litres (29,000 to 33,000 gallons) of diesel oil per year. Energy consumption is high because a shrimper is dragging heavy trawls about 80% of the time and, in some cases, may also be providing power for on-board freezing facilities.

To increase fuel efficiency, the existing propulsion system on the "Jean Colette" — a Gulf Based Shrimper — was retrofitted with a ducted nozzle designed by Kort Propulsion Company Limited of England and a fixed-pitch Kort propeller. In this demonstration, the new ducted propulsion system resulted in a significant fuel saving and other benefits.

Photograph: Bill McDermott

The fishing vessel "Jean Colette" with its ducted propulsion system

Benefits:
- The installation of the Kort Nozzle and fixed-pitch propeller reduces annual diesel fuel consumption by about 20%.
- Consequently, emissions of combustion products are also reduced by approximately 20%.
- The saving of $12,728 in annual fuel costs makes the vessel a more profitable enterprise.

ENERGOPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENERGOPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

- By reducing fuel costs for propulsion, on-board freezing of the catch is now a cost-effective option. This results in two further benefits. First, if frozen within two hours of being caught, the quality of shrimp is improved. Second, the fisherman can sell the frozen shrimp directly on the market, which brings a higher price than selling fresh shrimp to a fish plant.
- As a result of this project, a Canadian firm, H.M.W. of Dartmouth, N.S., built the Kort nozzle under licence and gained valuable experience for future applications.

Performance:

The demonstration is considered a complete success. The 20% reductions in fuel consumption and exhaust emissions, under actual fishing conditions, were as expected. Annual fuel savings were 36,368 litres (8,000 gal) — an annual savings of about $12,728 @ $0.35/litre.

Installation of the new propulsion system took place in 1982 and was more expensive than expected due to the inexperience of the installers. As experience is gained, installation costs are expected to decline. Nonetheless, anyone purchasing a ducted propulsion system is advised to secure a firm price on equipment and installation.

Actual performance testing, using various sensors and an on-board computer, was carried out before and after installation of the Kort nozzle. The following conclusions were reached:

- The maximum attainable bollard pull was increased from 45.88 kN (10,300 lbs) to 62.22 kN (13,967 lbs) — a 35.6% increase.
- In the bollard pull condition, the maximum main engine rpm attainable before overloading was increased from 1,050 to 1,160.
- The original maximum bollard pull of 45.88 kN (10,300 lbs) @ 1,051 rpm, can now be attained at 995 rpm and the rate of fuel consumption is reduced by approximately 12 litres/hour (2.6 gal/hour) at that point.
- In a port departure condition, the original maximum attainable free running speed of 9.37 knots was reduced to 9.25 knots. This reduction of 0.12 knots (1.28%) is virtually undetectable and, due to the associated reduction in main engine rpm, fuel consumption is decreased by approximately 4%.

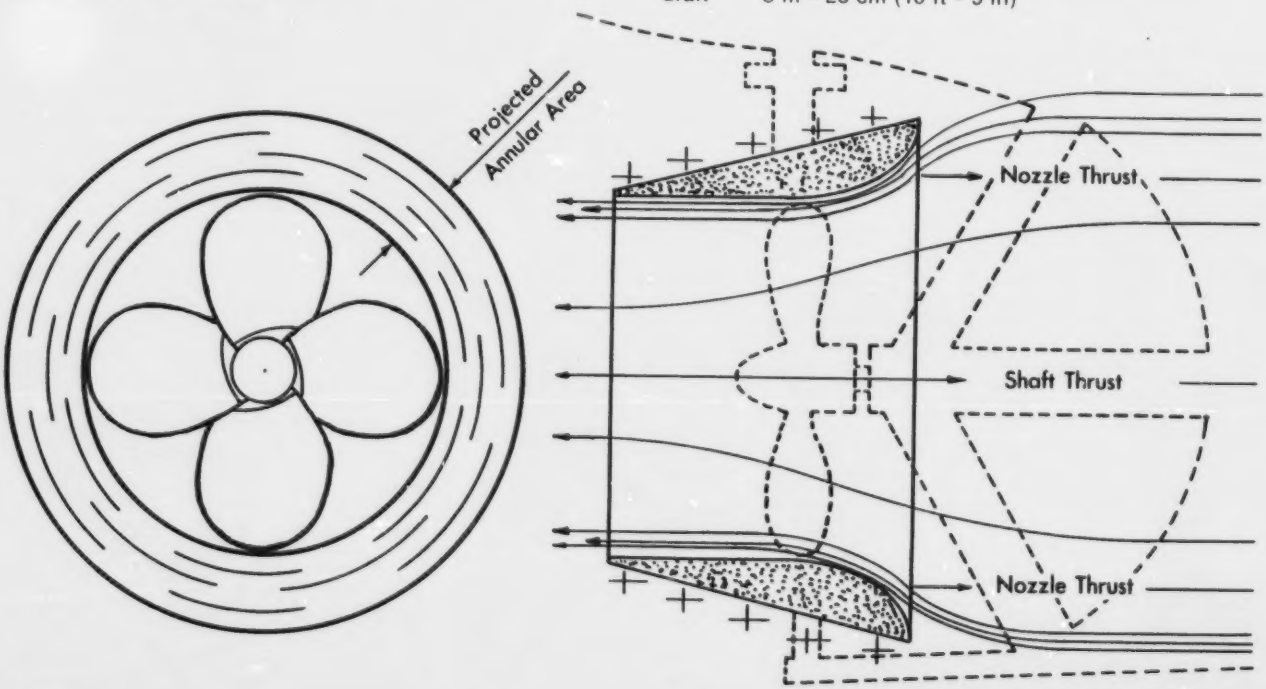
Performance tests also showed that the ducted propulsion system is best suited for stern draggers as it makes side draggers (such as the "Jean Colette") slightly more difficult to steer.

Technical Details:

A ducted propulsion system reduces fuel consumption in two ways: first, propeller losses at the blade tips are eliminated because the blades are enclosed in a cylinder; and second, the nozzle produces thrust as a result of the negative pressure effect of water flowing over a hydrodynamic shape. The figure shows these effects.

The demonstration vessel was the M.F.V. "Jean Colette", owned by Captain Pamphile Légère. Its principal dimensions are:

length	22 m - 12 cm (72 ft - 7 in)
breadth	6 m - 32 cm (20 ft - 9 in)
draft	3 m - 28 cm (10 ft - 9 in)



Theoretical action of a nozzle

The vessel is powered by a Caterpillar diesel engine (380 Bhp. @ 1,250 rpm) with a reverse/reduction gearbox (ratio 4.087:1). The original propeller was a 4 blade, manganese bronze open propeller with diameter 168 cm (66 in); pitch 117 cm (46 in); and B.A.R. -0.55.

The selection of the new nozzle and propeller was based on consideration of the following vessel data:

- length
- breadth
- draft
- propeller clearance
- engine h.p.
- marine gear reduction ratio
- sailing speed
- towing (fishing) speed
- engine fuel consumption

Three possible system configurations were considered. These were:

- the Kort nozzle coupled with the vessel's existing propeller
- the Kort nozzle coupled with a variable-pitch propeller
- the Kort nozzle coupled with a Kort fixed-pitch propeller.

The last system was selected on the basis of cost-effectiveness. The second option, a Kort nozzle coupled with a variable-pitch propeller, would have provided the highest fuel savings (about 30%) but would have been two to three times more expensive to install and would probably incur higher maintenance costs.

Economic Analysis:

Capital and Installation Costs: $23,000

Simple Payback Period: 1.8 years

Annual Fuel Savings:
(36,368 L @ $0.35) $12,728

Availability:

The nozzle was designed by Kort Propulsion Ltd. of England and built, under license, by H.M.W. (Halifax Metal Workers) in Dartmouth, Nova Scotia.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Energy Secretariat
  Government of New Brunswick
  P.O. Box 6000
  Fredericton, New Brunswick
  E3B 5H1
  (506) 453-3897

The Kort nozzle and propeller were built by:

- H.M.W. Industries Ltd.
  P.O. Box 756
  Halifax, Nova Scotia
  B3J 2V2
  (902) 469-7760

Information on this demonstration project is also available from:

- Herman Branch
  Fisheries School
  New Brunswick Department of Fisheries
  Caraquet, New Brunswick
  E0B 1K0
  (506) 727-6581
- Captain Pamphile Légère
  F.V. "Jean Colette"
  Box 6, Suite 8
  Caraquet, New Brunswick
  E0B IK0
  (506) 727-5267

Wood-Chip Burner

BROOKDALE NURSERIES

Technology:
Small-scale, direct combustion of wood residues

Demonstration Project Manager:
Lloyd Brown
President
Brookdale Nurseries Ltd.
P.O. Box 422
Newcastle, New Brunswick
E1V 3M5
(506) 622-3424

Location:
Newcastle, New Brunswick

Annual Savings: Approximately $30,000
62% of previous heating costs

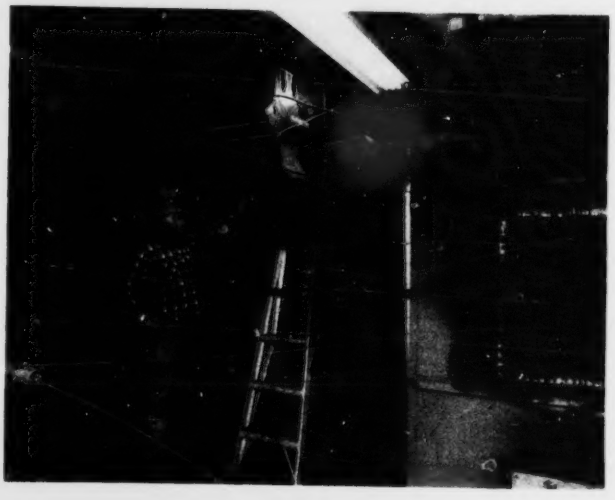
Payback Period: 3 years

Applicable to:
- Greenhouses
- Food Processing
- Hospitals
- Nursing homes

Description:
Brookdale Nurseries, one of New Brunswick's largest greenhouse complexes, is now using wood chips to fire boilers originally designed for oil. Brookdale Nurseries is a .75 hectare (1.85 acre) complex consisting of 17 greenhouses, a retail display area, a farmers' market; and office, maintenance and stock areas. It was formerly heated by four 250 hp, oil-fired steam boilers and one 60 hp boiler. In late 1981, one of the large boilers was modified by replacing the original oil-burner with a Dutch Oven type combustion chamber burning wood chips. The oven is attached at the firing end of the boiler and connected by a refractory-lined collar.

Roundwood and slabs are chipped on site, stored in a day bin, and supplied to the oven by a chip handling system which is controlled automatically by the steam pressure in the boiler.

The system was designed and built largely by the owner of the Nurseries. In places, it uses equipment which was on hand and adapted to the system.



Benefits:
The conversion of the first boiler to wood chips has produced the following benefits:
- a net saving in fuel costs of about $30,000 per year, or 62% of previous costs;
- reduced air emissions compared to roundwood or oil;
- local employment and income produced in supplying and chipping wood;
- maintenance of existing greenhouse jobs through a more economic operation;

The owner was so satisfied with the results on the first boiler, that he subsequently converted a second large boiler to burn wood chips.

ENEROPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENEROPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Performance:

The wood-chip boiler was monitored for the seven months of the 1983/84 heating season and demonstrated the following performance:

- Overall fuel consumption was 420 tonnes (460 tons) of wood chips at 20% moisture content wet basis (25% moisture content dry basis).
- Total production of steam at 40 kPa (6 psig) was 2.1 million kg (4.6 million lbs).
- System efficiency ranged from 69.5% with undried chips at a low capacity factor of 45.9% to 84.6% with dried chips at a high capacity factor of 75.7%. These values were about 10% higher than expected.
- Stack emissions were quite clean, with a smoke number of 1 (cleaner than oil).
- The burner and boiler were operating at only 20 to 25% of full capacity — far below their potential.
- There were occasional jams in the fuel feed system caused by over-sized chips.
- The excess air supply to the Dutch Oven varied from 50% to a more typical 260%. This contributed to low stack temperatures and carry-over of fly ash into the boiler-tubes.

Several recommendations were made to increase the system output including:

- An increase in the fuel feed rate by doubling or tripling the auger speed;
- Installation of a fuel spreader device to obtain better fuel distribution over the grate;
- Adjustment of the combustion air supply to reduce excess air to about 50%.

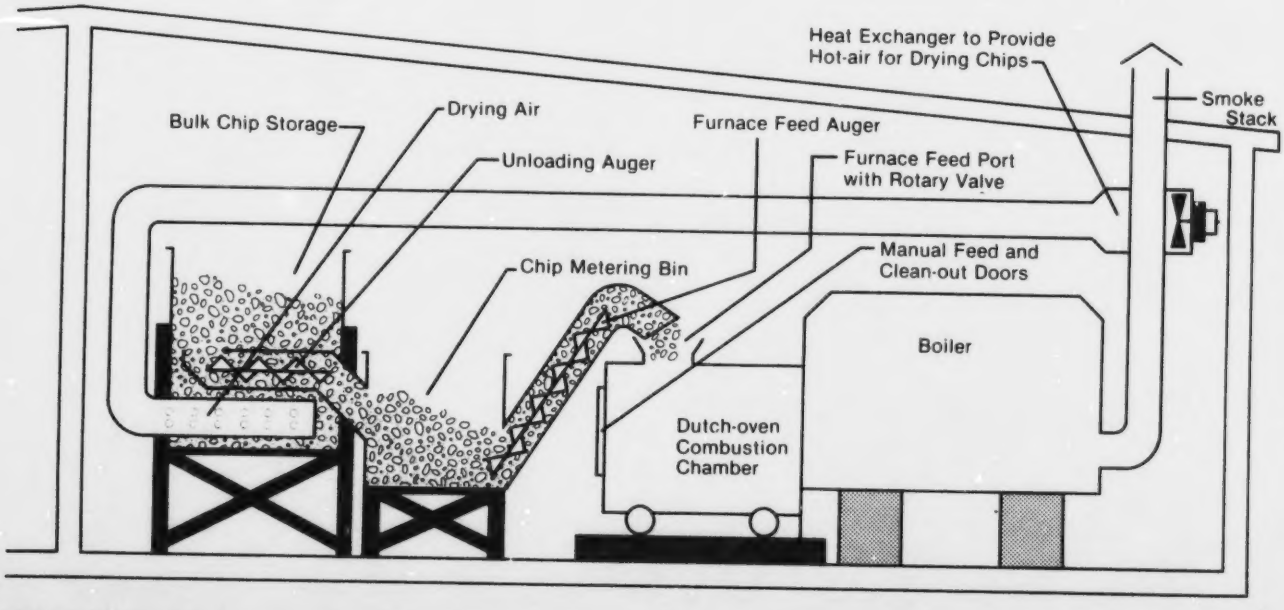
To reduce the fuel jamming problems, two solutions were tried, with success:

- Installation of a screen to remove over-sized chips;
- Removal of the rotary valve at the top of the Dutch Oven, which tended to jam.

Technical Details:

The Brookdale Nurseries greenhouse complex consists of 17 conventional greenhouses covering 0.75 hectares (1.85 acres), a retail display area of 370 m^2 (4,000 ft^2), a farmers' market of 186 m^2 (2,000 ft^2), a tropical plant display area, heated office, packing room, stock rooms, maintenance shop and connecting corridors. The complex is heated by a low pressure steam system operating at 40 kPa (6 psig), which is supplied by four 250 hp boilers and one 60 hp boiler, all formerly fired by fuel oil.

In late 1981, one of the 250 hp boilers, built by Dominion Bridge (model 250-06-3), was converted from fuel oil to wood chips by completely removing the original oil burner and attaching a custom-made Dutch Oven type combustion chamber. Connection to the boiler is made by means of a refractory-lined collar carried in a steel housing welded to the boiler front. The Dutch Oven is made of structural steel sections and steel plate welded into a box-like structure 2.4 m (8 ft) long by 1.8 m (5.75 ft) high by 1.7 m (5.5 ft) wide. The frame is mounted on wheels which run on steel tracks so that the Dutch Oven can be rolled back to enable boiler cleaning. The combustion chamber walls are lined with insulating firebrick and the arched ceiling is lined with cast-in-place refractory material. Combustion takes place on a horizontal cast iron grate 0.9 m (3ft) by 1.8 m (6 ft) located 0.3 m (1 ft) from the bottom. Combustion air is preheated in a plenum over the combustion unit — thus recovering heat which would otherwise be lost — and is delivered to primary air ports below the grate and secondary air ports 0.5 m (1.5 ft) above the grate. Ash is collected below the grate and scraped out periodically through hatches at the front and sides of the oven. Fly ash collects in the fire-tubes of the boiler to the point of constriction and is then removed by allowing the fire to burn out, rolling the oven away from the boiler and cleaning the tubes manually with a tube brush.



Hardwood and softwood are supplied by local cutters, are chipped on site using a Bruks chipper and stored in a shed. The chips are then moved by a farm tractor with a loading bucket and are dumped through a 15 cm (6 in) screen into an agricultural forage blower. The blower delivers the chips to a stationary forage wagon equipped with a scraper chain live bottom driven by a 20 hp electric motor. (See schematic diagram.) The transverse screw conveyor of the forage wagon then loads the chips into a metering bin, from which the chips are fed, upon demand, into the Dutch Oven via an inclined screw conveyor and finally a rotary valve. The conveyor is controlled automatically by steam pressure changes in the boilers.

Finally, heat recovered from the boiler stack is used to provide partial drying of the chips in the bulk storage bin.

Economic Analysis:

Project Capital Costs

• Equipment	$76,283	
• Installation	$10,473	
Total:	$86,756	

Operation and Maintenance Costs
(for 83/84 heating season)

• Value of displaced oil 216,000 L @ $0.22/L		$47,520
• Cost of wood fuel 420 tonnes @ $40/tonne	$16,800	
• Cost of electricity for feed system 24,224 kWh @ $0.05/kWh	$ 1,211	
	$18,011	($18,011)
Net Annual Savings:		**$29,509**

Simple Payback Period: 3 years.

Notes:
The delivered value of wood chips at $40/tonne ($44/ton) is based on the cost of wood at $22-$23/tonne ($24-$25/ton), plus chipping at $7-$8/tonne ($8-$9/ton) plus amortization of equipment at $9-$11 tonne ($10-$12/ton). The electrical costs include electricity for the fuel feed auger, forced and induced draft fans, feedwater pump, rotary air valve and all boiler controls but not for the motor for the live bottom day bin. This is approximately balanced by the inclusion of the feedwater pump and the saving on the retired oil burner.

Availability:

Mr. Lloyd Brown, the owner of Brookdale Nurseries, is a licensed stationary engineer as well as a plumber and electrician. These skills allowed him to design and build much of the system himself, partly by adapting farm machinery obtained from his farm equipment business. It is recommended that an experienced consulting engineer be used by those without such capabilities.

The steel fabrication was undertaken by York Steel of Fredericton, New Brunswick, and the refractory material was supplied by A.P. Green Refractories of Moncton.

Further information:

Further information on this system and a copy of the final technical report are available from:

- ENEROPTIONS
  Energy Secretariat
  Government of New Brunswick
  P.O. Box 6000
  Fredericton, New Brunswick
  E3B 5H1
  (506) 453-3897

The project manager and system owner is:

- Lloyd Brown
  (re: ENEROPTIONS)
  Brookdale Nurseries Ltd.
  P.O. Box 422
  Newcastle, New Brunswick
  E1V 3M5
  (506) 622-3424

Integrated Energy Management System

CONNOR BROS. LTD. — BLACK'S HARBOUR, NEW BRUNSWICK

Technology:
Energy retrofit systems:

- Interface between a programmable microprocessor and a microcomputer to log and analyze energy use
- Control and monitor electrical power loads and temperatures with a programmable microprocessor
- Waste heat recovery from plant hot air sources, refrigeration systems and hot waste water streams

Demonstration Project Manager:
W.N. Walsh
Connors Bros. Ltd.
Black's Harbour, New Brunswick

Location:
Black's Harbour, New Brunswick

Annual Savings: $79,472

Payback Period: 2.3 years

Applicable to:
A wide variety of industrial applications.

Description:
The innovative interfacing of a programmable process controller with a microcomputer is translating into energy and money savings for Connors Bros., North America's largest sardine canner.

This energy management system effectively measures and regulates both electrical and heat energy consumption at the company's Black's Harbour fish processing plant in New Brunswick. Significant savings result when waste heat from the plant's hot water sources is reclaimed to preheat boiler makeup and clean-up water. In addition, hot air normally exhausted is used for space heating in cooler areas of the plant.

The Programmable Logic Controller:

- controls the power factor
- controls an air compressor for intermittent cycling
- controls and monitors air temperatures
- monitors the water temperature of the heat recovery system
- reduces peak electrical demand through automatic control of non-essential electrical equipment

ENEROPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENEROPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Benefits:

- There are annual savings in total energy costs of $79,472.
- Recycling the plant's air saves $29,052.
- Recovering and recycling hot water from plant operations results in savings of $29,709 a year.
- Control of electrical consumption and demand results in annual savings of $20,711.
- The microcomputer can store and analyze large amounts of data, enabling management to optimize the use of the plant's energy consuming systems.

Performance:

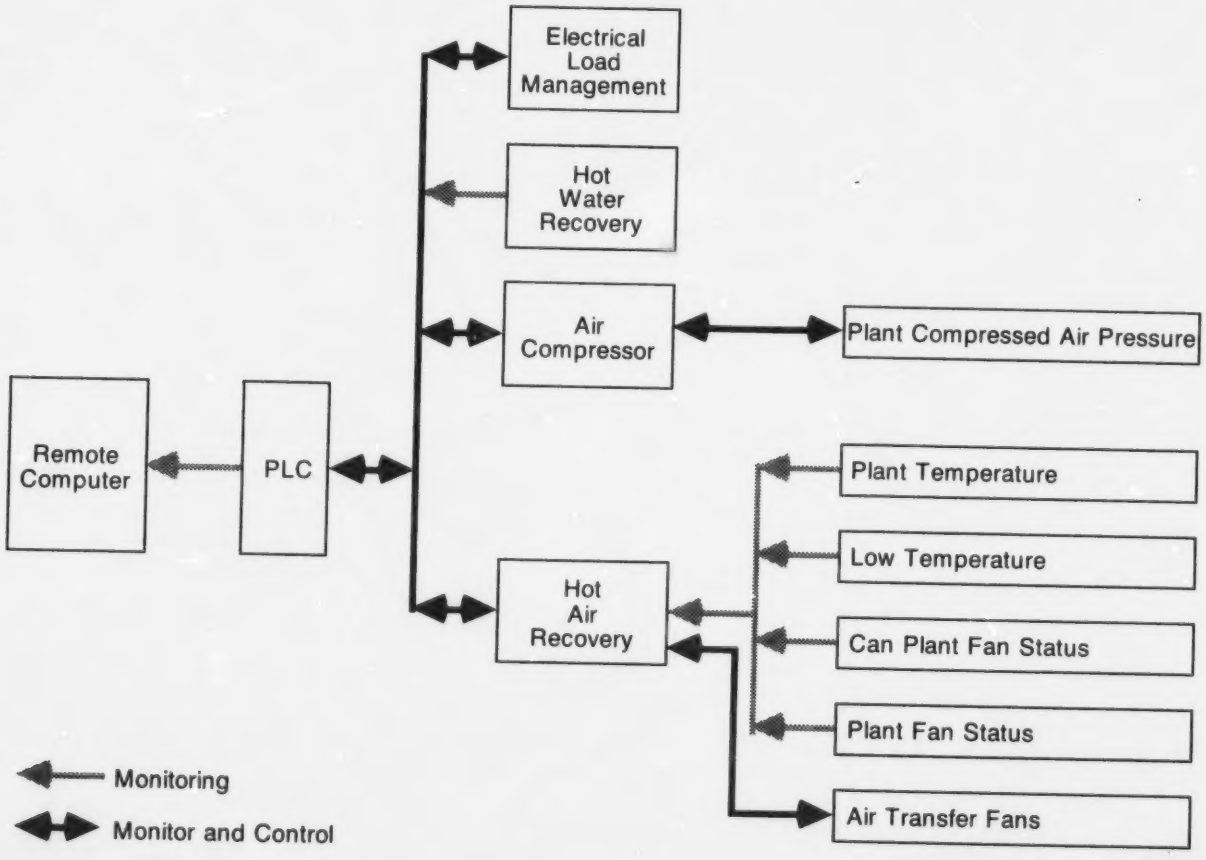
The installation, operation and maintenance of the energy retrofit systems proceeded as predicted and overall performance exceeded original projections for the project.

- Heat from approximately 60% of the previously exhausted hot air is recovered.
- About 69% of the recovered hot water energy is used; 27 GJ/day (26×10^6 Btu/day) is recovered through the waste water system, of which 19 GJ/day (18×10^6 Btu/day) is used in various operations.
- The plant's power factor is controlled to 92% lagging.
- Up to 226 kW of connected load is shed in stages to control the peak power demand.

Technical Details:

In 1982, Connors Bros. Ltd. began retrofitting several potential energy saving technologies in the areas of heat recovery and electrical energy cost control. These technologies were combined into one integrated energy management system, based on automatic monitoring and controlling of energy use with a programmable controller and a microcomputer, as illustrated in the schematic diagram.

Installation took place from March 1, 1982 to October 1, 1982. The reported monitoring period ran from October 1 in 1983 to March 31, 1984.



Monitoring and Control System

- An Allen-Bradley (PLC 2/30) Programmable Logic Controller was installed to monitor and control electrical loads, air temperatures and other energy usages throughout the plant. An hourly record of the input/output status is recorded on an EPSON MX-80 printer. Since the PLC was not designed to analyze data, an interface with an Apple IIe Computer was required. The Apple stores and analyzes the data and generates reports of energy usage to help identify problem areas.

Hot Air Recovery

- The control of plant air temperature is achieved by the PLC. Depending on the heating or cooling requirements, five hot air recovery makeup or six exhaust AEROPROP fans transfer air between areas of the plant and control the space temperature to within 2° C (3.6° F) of set point. Eighteen Can Arm 137 cm (54 in) ceiling draft fans are installed to recirculate the warm air.

Hot Water Recovery

- An insulated 22,730 L (5,000 gal) steel tank is installed to collect clean hot water recovered from the following four sources:
  - — Four air compressors
  - — Boiler continuous blowdown
  - — Boiler oil preheaters
  - — Refrigeration system heat exchanger

  The water is used for plant cleanup and to preheat boiler makeup water.
- The reclaimed waste heat from the can washers is transferred directly to its own makeup water via a Patterson-Kelly plate heat exchanger.
- These systems are not controlled by the PLC. Only the temperature is monitored to determine the system's effectiveness.

Electrical Control

- The primary electrical service is subdivided into two sections. Power consumption is monitored on each section while one power factor transducer is provided for the entire distribution system. The system's kW demand, power factor and kVA demand is calculated by the programmable controller (PLC). Peak load shedding and power factor correction programs are actuated automatically by the PLC as needed. The objectives are to reduce the monthly peak electrical demand and to maintain a minimum system power factor of 0.92.
- It is the intention to extend the existing equipment to control other energy consuming sources in the plant (e.g., lighting sytems and the cycling of non-essential electrical loads to decrease further peak demands).

Economic Analysis:

Project Costs:

Items	Installation	Equipment
1. Hot Water Recovery		
— Tank	$12,795	$ 4,205
— Refrigeration	2,365	12,635
— Can Washers	2,272	5,728
2. Hot Air Recovery	3,769	14,231
3. Monitor and Control	13,411	26,589
4. Programmable Controller	5,872	44,123
5. Design and Engineering	11,000	—
6. Computer Interface*	6,803	13,197
Total	$58,287	$120,708
Total Installed Cost		$179,000

*(Apple IIe microcomputer plus Software Interface).

Annual Savings:

Area	Savings
1. Hot Air Recovery	$29,052
2. Hot Water Recovery	
— Tank	7,740
— Refrigeration	4,035
— Can Washers	17,934
4. Electrical Load Management:	
— Power Factor	5,453
— Peak Load Shedding	13,470
— Air Compressor Cycling	1,788
Total	$79,472

Simple payback period: 2.3 years.

The ultimate payback period is uncertain due to variations in annual fish landings which determine production and energy use.

Availability:

Connors Bros. Ltd. designed and installed the project system themselves.

The technology, supplies and services are available throughout Canada. The engineering design and implementation of the different technologies may require the services of competent specialists.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Energy Secretariat
  Government of New Brunswick
  P.O. Box 6000
  Fredericton, New Brunswick
  E3B 5H1
  (506) 453-3897

Information on the demonstration project is also available from the major supplier:

- Allen-Bradley Canada Limited
  (re: ENEROPTIONS)
  135 Dundas Street
  Cambridge, Ontario
  N1R 5N9
  (519) 623-1810

University Energy Efficient Retrofit

MOUNT ALLISON UNIVERSITY — SACKVILLE, NEW BRUNSWICK

Technology:
Comprehensive energy retrofit

Demonstration Project Manager:
Kirk Bavis
Enerplan Consultants Ltd.
86 Botsford Street
Moncton, New Brunswick
E1C 4X3
(506) 854-5536

Location:
Sackville, New Brunswick

Annual Savings: $157,420

Payback Period: 7.6 years

Applicable to:
- Small universities and community colleges
- Institutional clusters, such as hospital complexes
- Swimming pools and ice arenas
- Older building envelope energy retrofits

Description:
Mount Allison University is saving $157,420 per year in total energy costs. Founded in 1893, the university consists of 45 buildings with a total floor space of 86,025 m^2 (926,000 ft^2). The buildings are used for academic, athletic, artistic and residence purposes and range in age from 20 to 80 years. Most are constructed of brick, block and sandstone. Student population was 1,750 in the 1984-85 school year, up 22% from 1981-82.

Through an integrated renovation and comprehensive energy retrofit and management package, Mount Allison University will realize an acceptable payback on its energy investment of $1,200,000 as well as creating a better learning environment by increasing comfortable, usable space. The energy package includes:

- Building envelope and systems retrofits;
- Heat reclaim from exhaust heat, especially in kitchen areas;
- Heat reclaim from swimming pool dehumidification;

- An improved control system for steam distribution;
- A computerized central energy monitoring and management system.

Benefits:
- It is estimated that the energy management and retrofit package will result in annual savings of over $160,000.
- Building envelope retrofits resulted in improved living conditions and comfort levels. Residences previously unfit for habitation (too cold and drafty) are now comfortable and occupied.
- The energy monitoring and management system reduces the time required for system trouble-shooting and allows for systematic delivery of preventative maintenance to energy-related equipment.

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Performance:

The demonstration has proven the viability of energy conservation retrofits combined with energy management systems for small universities. Monitoring of this project began in 1984.

All installed retrofits and energy management systems are now performing as, or better than, expected.

The total cost of all energy related work was $1,200,000 with realized savings of $157,420 per year.

Air infiltration for residence rooms was reduced by from 43% to 85%.

The insulation of steam pipes reduced heat loss in the steam tunnel with a resulting steam tunnel temperature of 32°C (90°F) in the winter. As a result, tar no longer melts out of tunnel electrical boxes.

Air handling systems were installed in several buildings. In one, heat to the basement is shut off at night but, with the installed air circulation system, no freeze-ups in the basement have occurred.

The pool dehumidification system has stopped window condensation and frosting, reduces moisture damage to interior surfaces and reclaims heat previously exhausted to the outside.

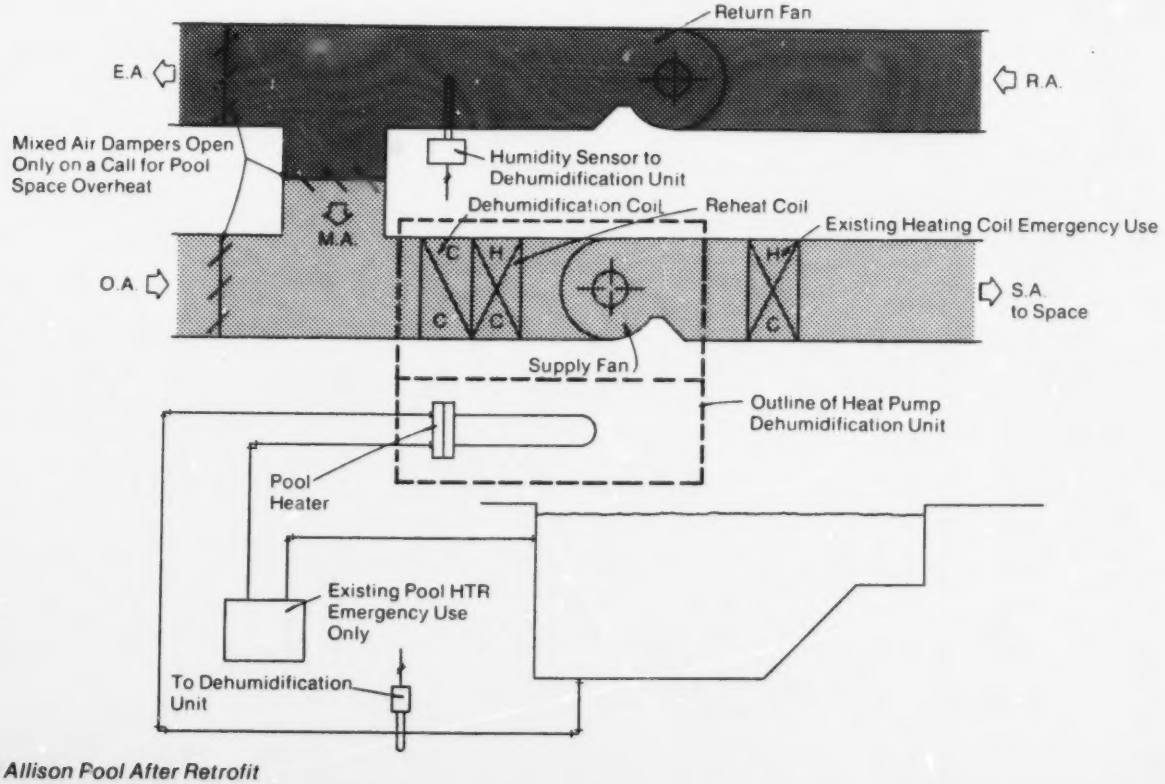
The energy management and monitoring system provides accurate information on the energy performance of all buildings. Prior to installation, there were only three electric power meters for the entire university. Now each building has its own steam and electric meters. Some problems were experienced at start-up with faulty electric relays and steam meter inaccuracies. These have since been remedied. Electrical demand scheduling equipment has been installed. Load shedding capacity amounts to approximately 65 kW, and this can be increased to 200 kW.

Technical Details:

The Mount Allison University demonstration has combined many energy retrofit and management elements. These are:

- Building envelope retrofits, especially insulation, air sealing and window replacement;
- Replacement of steam distribution valves to allow zone control and re-insulation of the steam system;
- Reduced hot water temperatures and the installation of restricted-flow shower heads;
- Installation of a computerized energy management and monitoring system (EMMS);
- Upgrading of air handling and exhaust systems;
- Installation of heat reclaim systems on exhaust heat, especially that from kitchens and shower-rooms;
- Installation of heat reclaim and pool dehumidification systems;
- Installation of boiler oxygen trim controls;
- Installation of radiator thermostatic valves;
- Retrofits to building lighting systems.

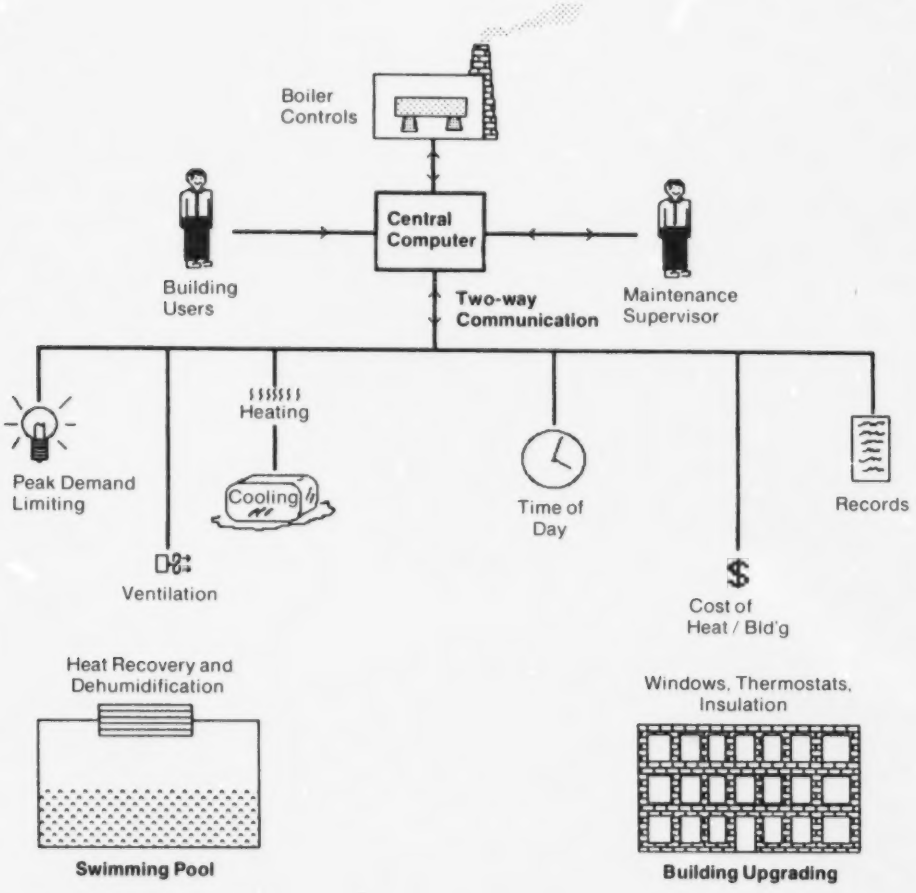
Details on the EMMS and pool heat reclaim system follow.



Mount Allison Pool After Retrofit

The EMMS ties all energy controls into a central computer, which monitors energy requirements with current conditions to provide cost-effective energy delivery. The system monitors, through remote sensing devices, steam and hot water circulation, on/off status of air handling equipment, heating and cooling valve pressures, supply air temperature and actual electric consumption. These are fed to a central mini-computer, a Digital RLO-2 MC Powers System 600 which provides read-outs on all monitoring data at any given point in the entire university complex and provides control functions. The system also has load shedding capacity.

The swimming pool has a water temperature of 27° C (80° F). Prior to retrofit, excess humidity was exhausted to the outside with a subsequent heat loss and the need to heat incoming cold fresh air. A DRY-O-TRON heat pump dehumidifier was installed. The cooling unit was installed in the exhaust duct to remove water from the air. Condensed water is returned to the pool. The heat pump recovers heat from exhaust air to heat pool water and makeup air.



System Highlights: Energy Efficient Retrofit

Economic Analysis:

The energy demonstration project cost 1.2 million dollars. Of this, the pool dehumidification cost $65,000 and the energy monitoring and management system cost $186,000.

Renovation work completed in conjunction with the energy related work cost an additional $936,000.

Energy savings are $157,420/year, and measured against the 1.2 million dollar investment, represent a simple payback period of 7.6 years. As operating experience and quality of data increase, savings continue to grow, further lowering the payback.

Availability:

All of the systems and equipment installed are available nationally.

Further Information:

Further information and a copy of the final report are available from:

- ENEROPTIONS
  Energy Secretariat
  Government of New Brunswick
  P.O. Box 6000
  Fredericton, New Brunswick
  E3B 5H1
  (506) 453-3897

- Kirk Bavis
  (re: ENEROPTIONS)
  Enerplan Consultants Ltd.
  86 Botsford Street
  Moncton, New Brunswick
  E1C 4X3
  (506) 854-5536

Surface-Heated Greenhouse Using Waste Heat

N.B. POWER — GRAND LAKE, NEW BRUNSWICK

Technology:
Surface heating system for commercial greenhouses using low temperature waste water

Demonstration Project Manager:
New Brunswick Coal Ltd.
P.O. Box 520
Minto, New Brunswick
E0E 1J0

Location:
Grand Lake, New Brunswick

Annual Savings: $7,000
30% of cost in conventional greenhouse

Payback Period: 3½ years

Applicable to:
Commercial glass-covered greenhouses located near a source of warm waste water

Description:
In this innovative surface heating technique, the greenhouse itself is used as a heat exchanger. Warm waste water from a power plant is allowed to cascade over the outside surface of a commercial glass-covered greenhouse. The warm water provides an insulating barrier without reducing light levels.

Two 940 m^2 (0.23 acres) greenhouses were built adjacent to N.B. Power's Grand Lake Generating Station — the control greenhouse heated by a conventional propane hot water heating system, the other heated by waste warm water from the power plant using the surface heating technique with conventional propane backup. The two greenhouses were operated for one year while heating requirements, temperatures, humidity, and crop yields were monitored.

Benefits:
- Conventional heating requirements for the surface-heated greenhouse are reduced by 30% over the year.
- A net annual savings of $7,000 is realized.
- The conventional (backup) heating plant size is reduced.
- Snow build-up is eliminated from the roof thus removing the risk of collapse from excessive snow load.
- Crop yields are unaffected.

ENERGOPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENERGOPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Performance:

The surface heating system was operated and monitored without major problem for the period of March 1983 to March 1984 by greenhouse personnel with no special training. Crops of tomatoes were grown in both greenhouses and the humidity, carbon dioxide levels, and yield were monitored. While the humidity levels in the surface-heated greenhouse were slightly higher, crop yields and quality were almost identical (within 0.5%). The tomatoes were sold locally.

The heating requirements for the surface-heated greenhouse were, depending on the outside temperature, between 15% and 42% lower than those for the conventionally heated greenhouse. The monthly savings were found to be directly proportional to the temperature of the waste water which varied between 10° C and 14° C (50 and 57° F), and inversely proportional to the average outside temperature which varied between -9° C and 4° C (15 and 40° F) during the heating season. The average 12 month reduction in heating requirements was 30%, which was equivalent to an energy savings of 860 MJ/m^2/yr (3,300 MBtu/acre/yr). The temperature of the waste water need not be greater than the inside set temperature for savings to be achieved.

There were no problems with large scale freezing on the greenhouse roof. Even at an air temperature of -37° C (-35° F) and a waste water temperature of 10° C (50° F), the water leaving the greenhouse surface was 4° C (40° F).

When ambient temperatures were below freezing, there were minor problems with icing in the waste water distribution header which runs along the peak of the greenhouse roof. This resulted in some unwetted patches which froze at the edges. The problem was resolved by pressurizing the header bi-weekly to clear any ice.

It has been shown in other surface-heated greenhouses that, above a water flow of about 2.0 litres/min/m^2 (1,500 USgpm/acre), percent energy savings are independent of water flow and length of flow path. This flow was used at Grand Lake and also appeared to be sufficient to provide good water coverage and eliminate snow accumulation on the roof.

The results from the demonstration were used to calculate that savings up to 70% might be achieved if waste water were available during the heating season at 24° C (75° F) and that 50% savings would be possible with a waste water temperature of 18° C (65° F).

In general, it has been shown that:

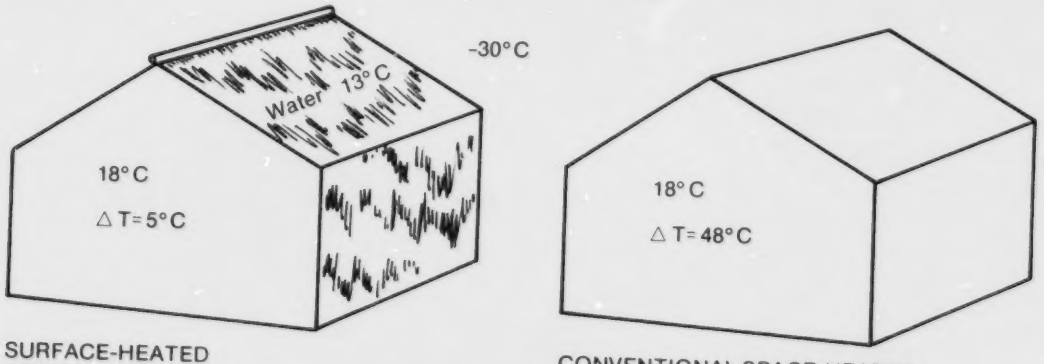
- Energy savings increase as water temperature increases
- Energy savings increase as outside temperature drops (i.e., colder climate)
- Energy savings increase as water flow increases (up to a point).

Technical Details:

The two greenhouses were standard, commercially-available, gutter-connected, glass-glazed units, each 46 m x 21 m (150 ft x 68 ft). They were built in late 1982 on an abandoned ash lagoon 450 m (1,475 ft) from the N.B. Power's 85 MW, coal-fired Grand Lake Power Plant, which is located 50 km (30 miles) east of Fredericton. Each unit included several energy conserving features such as insulated north walls, lap-sealed roof glazing, insulated ventilation covers, perimeter insulation, and inflated double polyethylene-covered side walls. The two units were connected by a small utility building housing the propane hot water heating systems and monitoring equipment. This building also provided a double entry into each greenhouse to reduce heat losses.

Warm water is pumped from the plant using a 120 hp pump via a 500 m (1,640 ft), 61 cm (24 in) diameter pipeline and is then distributed along the ridges of the surface-heated greenhouse through 15 cm (6 in) aluminum headers each containing two rows of 3 mm (1/8 in) holes spaced 8 cm (3 in) apart (one row each side). Runoff from the roof is collected in gutters and discharged to Grand Lake.

The greenhouses and their acessories were supplied by Paul Boers Greenhouses, St. Davids, Ontario and the pipeline was built by Minto Machine & Welding, Minto, New Brunswick.



SURFACE-HEATED GREENHOUSE

CONVENTIONAL SPACE-HEATED GREENHOUSE

In conventionally heated greenhouses, space heating must overcome a △ T of 48° C, versus only a △ T of 5° C for a surface-heated greenhouse. (example at -30° C)

The following parameters were monitored during the first 12 months of operation:

- Greenhouse temperature (8 locations)
- Greenhouse relative humidity
- Greenhouse carbon dioxide level
- Solar radiation (inside and outside)
- Waste water flow and header and gutter temperatures
- Heating system delivered energy (flow and temperatures)

Data were collected hourly and processed on a micro-computer located on-site. Monitoring was carried out by Marshall Energy Consultants, Fredericton, New Brunswick.

Economic Analysis:

Project Capital Costs

Installed cost of two conventional greenhouses: $688,000

Incremental installed cost of pipeline and surface heating system for 1 greenhouse: (est) $25,000

Annual O & M Costs and Savings

Reduction in heating costs using surface heating equipment:	$9,500
Cost of operating pump for surface heating equipment:	(2,500)
Net Annual cost savings:	$7,000

Simple Payback Period: 3½ years.

This analysis is based on a propane fuel price of $0.27/L ($11 per MBtu) and an 85% heating system combustion efficiency.

In general, the installed cost of a surface heating system may be assumed to be $27/m² ($110,000/acre) and the operating cost about $2.70/yr/m² ($11,000/yr/acre). In locations where waste water is available at 24° C (75° F) and propane or oil is used for greenhouse heating, it is estimated that simple paybacks as low as 1½ years may be achieved.

Availability:

The greenhouses and surface heating system were intentionally built with commercially available equipment at near commercial scale. No special equipment was required except for the brackets used to attach the waste water header to the ridge of one greenhouse. These were fabricated in a local machine shop. The gutter-connected greenhouses with energy conserving features were purchased from Paul Boers Greenhouse Ltd. All other equipment and supplies were available locally. No specially trained personnel were required during construction or operation.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  New Brunswick Energy Secretariat
  P.O. Box 6000
  Fredericton, New Brunswick
  E3B 5H1
  (506) 453-3897

Further information on this project is also available from:

- John Mercer
  (re: ENEROPTIONS)
  New Brunswick Power
  P.O. Box 2000
  Fredericton, New Brunswick
  E3B 4X1
  (506) 452-2052

ENERGY OPTIONS CASE STUDY

NB 50

Groundwater-Source Heat Pumps

NEW BRUNSWICK

Technology:
Groundwater-source heat pumps

Demonstration Project Manager:
Energy Secretariat
Government of New Brunswick
P.O. Box 6000
Fredericton, New Brunswick
E3B 5H1

Locations:
Deschenes Drilling Ltd., St. Quentin, New Brunswick
Gallant Residence, Fox Creek, New Brunswick
Weisseneder Residence, Rothesay, New Brunswick

Annual Savings: $570 to $2,350
64% to 73% compared to oil-fired heating

Payback Period: of as little as 0.9 years
on difference between oil and heat pump system costs

Applicable to:
Residential and commercial buildings in areas where an adequate source of groundwater is available.

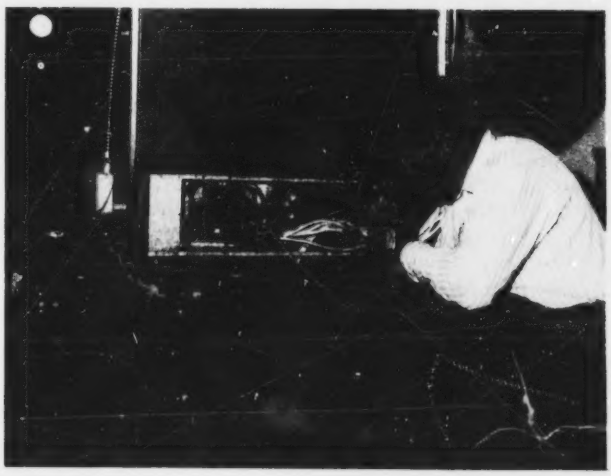
- space heating
- air conditioning and cooling
- domestic hot water heating

Description:
Performance monitoring, conducted in New Brunswick, demonstrated that groundwater heat pumps can be feasible alternatives to conventional oil-fired systems for heating. Annual energy savings in buildings equipped with these units ranges between 64% and 73%.

At Deschenes Drilling Ltd. in St. Quentin, New Brunswick, two groundwater heat pumps were installed, one in the residence/office and the other in a separate workshop. It was necessary to drill three wells at this project. One well to supply the heat pump for the residence and office area, the second for the workshop; the third well is the discharge well, common to both. These units provide both heating and summer cooling.

In the residences of Mr. R. Gallant of Fox Creek and Mr. K. Weisseneder of Rothesay, separate supply and discharge wells are used. In both residences, the heat pumps provide space heating and supplement domestic hot water requirements.

Due to the success of these projects, a number of groundwater-source heat pumps have been installed in New Brunswick.



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Benefits:

- Energy costs are reduced by $570 to $2,350 annually — a saving of 64% to 73%.
- Heat pumps can supply space heating requirements, can contribute to domestic hot water preheating, and can as well provide air conditioning in the summer.
- Using existing wells can lower system costs considerably (Well drilling costs often exceed $2,000).

Performance:

- The seasonal coefficient of performance (heat pump energy output divided by energy input), at the demonstration projects, ranged between 2.76 and 2.92.
- The seasonal performance factors (total energy output divided by total energy input, including water pumping) ranged between 1.97 and 2.37.
- The two major factors that affect performance are the temperature of the intake water supply and the depth of the water table; the latter factor affecting pumping energy requirements.
- The installation, operation and maintenance of these heat pumps proceeded as expected without any major problems. A freon gas leak was detected in one unit, but this problem was rectified without causing delays.

Technical Details:

A typical groundwater-source heat pump installation is illustrated in the schematic diagram.

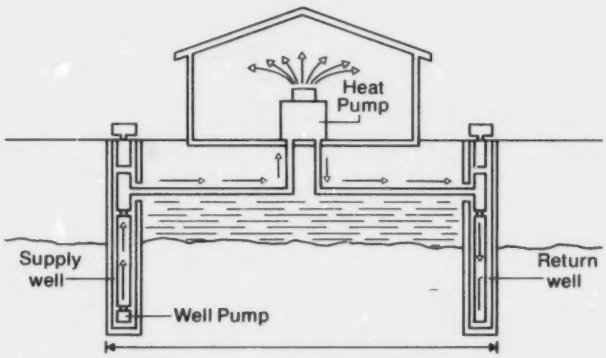
The demonstration heat pumps were installed in residences which ranged from an 89 m^2 (960 ft^2) bungalow to a 353 m^2 (3,800 ft^2) two-storey residence.

The capacities of the individual heat pumps range between 11.1 kW and 23.5 kW.

The models installed included a Permatemp TP 80, a Maritime Geothermal 036 (formerly Glencar) and an Aquatec 52 Hu.

During the monitoring year, the inlet water temperature from the wells ranged between 5.2° C (41.4° F) and 13.1° C (56.6° F). The extraction of heat from this water lowered its temperature by from 2 to 4° C (3.6 to 7.2° F).

On the hot air side, the heat pumps raised the temperature of the air passing through the coil from 20° C (68° F) to 35° C (95° F).



Economic Analysis:

In general, the replacement of existing heating systems with groundwater-sourced heat pumps cannot be justified on the basis of energy savings alone. They can provide a viable alternative for new buildings or where the existing system requires replacement. Often, the critical factor is the cost of the wells. Thus, the suitability of existing wells and the number and depth of new wells required should be examined carefully. Some of the other factors that affect the viability of this space conditioning approach include:

- The temperature of the groundwater
- The space conditioning load of the building
- Local climatic conditions and
- Local energy prices for oil and electricity

The following provides costs, savings and payback periods associated with these three demonstration projects:

Location	System Total Cost ($)	Assumed Cost of Conv. Syst.[1] ($)	Incremental Cost of H.P. System[2] ($)
Deschenes Drilling	14,544	12,336	2,208
Gallant Residence	5,916	2,780	3,136
Weisseneder Residence	8,464	3,776	4,688

Location	Energy Cost Savings[3] ($/yr)	Payback Total[4] (yrs)	Payback Incremental[5] (yrs)
Deschenes Drilling	2,349	6.2	0.9
Gallant Residence	572	10.3	5.5
Weisseneder Residence	1,272	6.7	3.7

(1) Conventional system assumed to be oil forced air (and air conditioning, where applicable).

(2) Difference between heat pump system and assumed cost of conventional system.

(3) Based on electricity price of $0.0427/kWh and oil price of $0.391/L.

(4) System total cost divided by energy cost savings.

(5) Incremental cost of the heat pump system divided by energy cost savings.

Availability:

Groundwater-sourced heat pumps are produced by a number of manufacturers and are often supplied by local distributors and heating contractors.

Further Information:

Further information and a copy of the monitoring report on these projects is available from:

- ENEROPTIONS
  Energy Secretariat
  Government of New Brunswick
  P.O. Box 6000
  Fredericton, New Brunswick
  E3B 5H1
  (506) 453-3897

The booklet, "Residential Groundwater Heat Pump", is available from:

- Energy Information Centre
  Manitoba Energy and Mines
  117-234 Donald Street
  Winnipeg, Manitoba
  R3C 1M8
  (204) 945-4154

Wood Residue Fuelled Boiler

UNIVERSITY OF NEW BRUNSWICK

Technology:
Large-scale, direct combustion of wood residues

Demonstration Project Manager:
John Dean
Northeast Energy Services Ltd.
1115 Regent Street
Box 44, Station A
Fredericton, New Brunswick
E3B 4Y2

Location:
University of New Brunswick, Fredericton

Annual Operating Savings: $820,000
72% of previous oil consumption

Payback Period: 3 years

Applicable to:
- Universities
- Schools
- Municipalities
- Large industry
- Hospitals
- Remote communities in areas where there is a secure supply of wood residue

Description:
The University of New Brunswick has returned to a New Brunswick tradition of wood heating for it's Fredericton campus — but with a high-tech twist. The University's district heating wood-fired boiler, the largest east of Montreal, provides space heating and domestic hot water for the entire university, two large apartment buildings, and the 485-bed Dr. Everett Chalmers Hospital. Since installation in 1970, the system has been serviced by two oil-fired boilers.

Under this project an 18,000 kg/hr (40,000 lbs/hr) wood-residue fired boiler was installed in the heating plant. It was designed to operate in a base-load mode in tandem with the oil-fired boilers and to displace 7 million L (1.5 million gals) of Bunker C oil annually. In addition, wood fuel storage silos and handling/feeding equipment were installed. The fuel is wood residues consisting of bark, sawdust, chips, shavings and harvesting waste. Apart from the large size of the facility, there are two other unique elements:

- The project was undertaken on an innovative turnkey basis, including savings financing through a 9-year contract between UNB and Northeast Energy Services Ltd.
- The wood fuel is supplied under a 9-year guaranteed contract and draws on residue from several wood processing plants within 60 km (37 miles) of Fredericton.

The wood residue fuelled boiler is installed in the central heating plant.

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Benefits:

Based on a 12 month monitoring period ending April 30, 1985, the following benefits were realized:

- A 72% contribution by the wood-fired boiler to the total load. This is higher than the projected contribution of 69% of annual requirements.
- The operating savings over this period were $820,000 based on displacing 7.05 million L (1.55 million gals) of oil worth $1,800,000.
- Acceptable emissions to the air in general and a reduction in SO_2 by burning wood in place of oil.
- A substantial demand for wood residues in the Fredericton area — the stimulus for creating a major wood residue infrastructure in central New Brunswick.
- Creation of nine person-years of new jobs in the heating plant and wood preparation facility.

Performance:

Overall during the monitoring period, the wood-fired boiler operated at or above expectations. The most significant results were:

- The boiler produced 107 million kg (235.4 million lbs) of steam, equivalent to 72% of the plant's total output.
- The amount of oil displaced was worth $1,800,000 in gross savings. Once the cost of wood fuel and incremental operating and maintenance costs (at an estimated total of $980,000) are taken into account, the net savings are $820,000. This is equivalent to a $7.74 saving per 1,000 kg ($3.48 per 1,000 lbs) of steam produced.
- The average moisture content of the wood fuel was 50.4% and the average boiler efficiency (input-output basis) was 68.2%. Combustion efficiency and steam output per unit of fuel varied inversely with the moisture content of the fuel.
- Overall quality of the wood fuel was important to both boiler efficiency and reliable operation of the fuel handling system. The key quality factors were moisture content, wood sizing and blend. The most satisfactory blend was 30-40% bark and 60-70% sawdust and shavings.
- The environmental controls operated effectively, removing over 90% of particulate matter, and achieved particulate emissions 65% below the regulatory standard.
- The optimum furnace draft to balance thermal efficiency and emissions was achieved by adjusting for 3% excess oxygen and 40% opacity.

Several relatively minor problems were encountered, particularly during the first 2 months of operation, and corrective actions were taken as follows:

- Wood fuel quality was low in the first few months. High moisture content caused silo clogging and reduced combustion efficiency. Oversized and stringy bark plus contamination with soil, rock and metal caused jamming in the wood transport system and excessive clinker build-up. These problems were overcome by installing a concrete pad for wood storage (thus reducing rock and sand carryover), a magnet to remove metal fragments, a disc screen and hogger to produce more uniform chips, reducing the amount of bark in the mixture to 30 to 40%, and making various adjustments to the woodfuel handling system.
- There was excessive clinker build-up in the boiler, necessitating shutdown and cleanout twice a day. This resulted from contaminants in the bark component of the fuel and lack of excess combustion air — both of which have been improved.
- Unexpected build-up of creosote on the dust collector tubes was improved by over-firing.
- Excessive friction and noise in the conveyor was corrected by the addition of Teflon wear strips.
- A complete boiler inspection, undertaken by Babcock-Wilcox, revealed only a minor loss of refractory around the inspection/cleanout door; this was repaired.

Technical Details:

The original steam plant, built in 1970, has two boilers firing number 6 (Bunker C) oil with a combined rated capacity of 54,500 kg (120,000 lbs) of steam per hour at 1,723 kPa (250 psig). The annual steam production for the plant has varied from a low of 150 million kg (330 million lbs) of steam to a high of 159 million kg (350 million lbs). The corresponding annual oil consumption was between 10.0 million litres (2.2 million gals) and 11.4 million L (2.5 million gals). The winter load rarely exceeds 45,350 kg/hr (100,000 lbs/hr) and the summer load is seldom less than 6,800 kg/hr (15,000 lbs/hr). The load factor is relatively high as a result of the hospital demand, which includes both domestic hot water and air conditioning in the summer.

The wood-fired boiler, built by Babcock-Wilcox, has a capacity of 18,000 kg/hr of steam (40,000 lbs/hr) at 1,723 kPa (250 psig) when firing wood fuel with a moisture content of 50% (wet basis). It was designed to handle the entire summer load and up to 60% of the winter steam demand. Installation of the new boiler took 6 months and was completed in March 1984. It is connected in tandem with the existing oil-fired boilers.

The wood fuel for the boiler is a mixture of bark, sawdust, chips, and shavings which is collected from four sawmills within a 60 km (37 mile) radius of Fredericton and then hogged and screened 2.5 km (1.5 miles) from the heating plant. The fuel is transported by large vans and dump trucks. Each load is weighed and a moisture content sample is taken. After dumping, the fuel is transported using a bottom scraper, screw conveyor, elevator buckets, and a chute to one of the two storage silos.

Each silo has a storage capacity of 136 tonnes (150 tons) of wood residue. Together they provide a storage capacity of two days at full load.

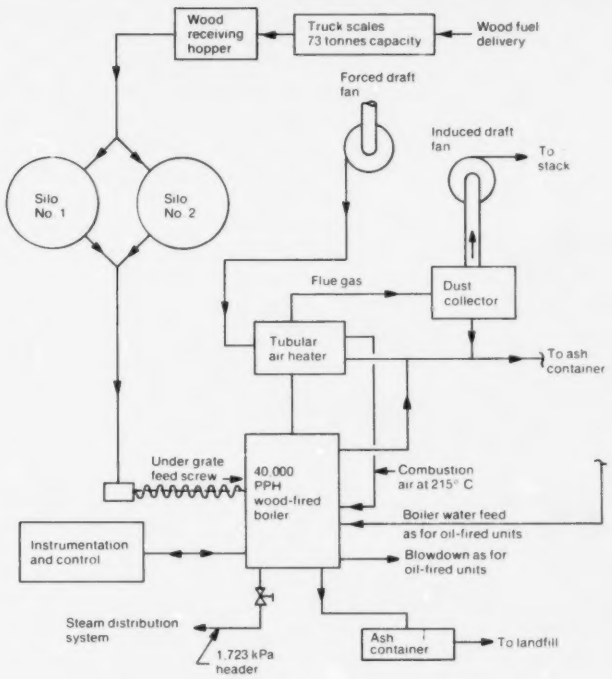
Wood fuel is discharged from the silos on demand using a chain flail-type agitator and is fed into a metering bin. From here it is transported via a variable speed screw (the feed rate of which is controlled by the load demand on the boiler) to a drag chain conveyor, which in turn feeds the boiler stoker screw. The entire wood fuel handling system can transport a maximum of 9 tonnes (10 tons) of fuel per hour to the burner.

The furnace itself is of the Towerpak Design with wood feed from an undergrate screw feeder with a centre discharge onto the pin hole grate. The combustion air is drawn from within the plant, preheated in a tubular heat exchanger to a temperature of 215° C (420° F) and directed into the combustion chamber in three different ways:

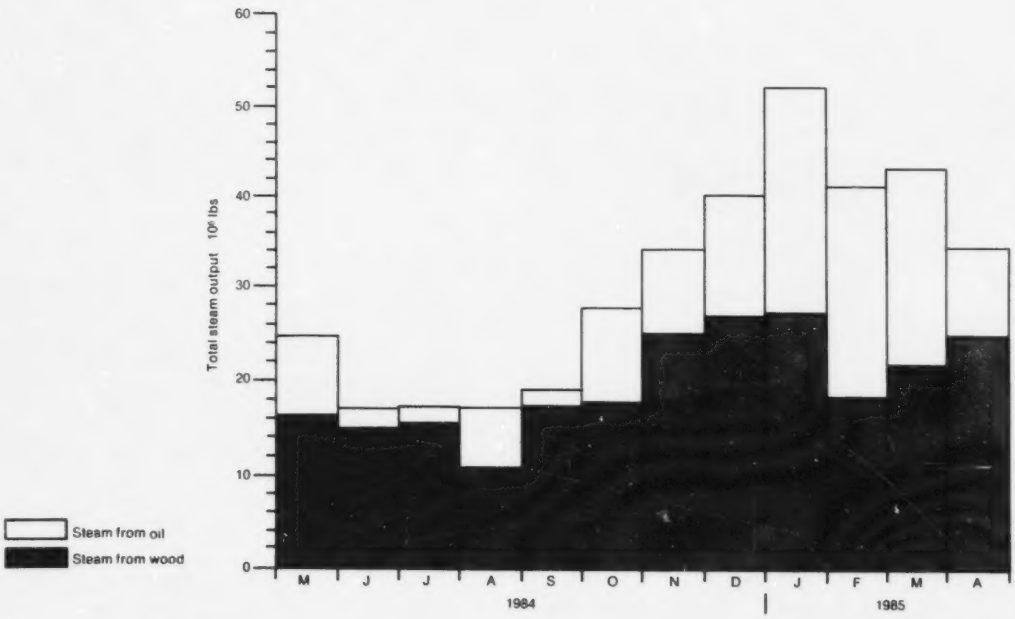
- Low pressure underfire air via pin hole grates to dry the fuel and provide primary combustion air;
- Low pressure overfire air via a peripheral plenum 0.6 m (2 ft) above the grate;
- High pressure overfire air from a high pressure fan via a duct 1.2 m (4 ft) above the grate to ensure complete combustion and minimize carry-over of unburnt wood to the exit gas.

The combustion gases leave the furnace area and pass through the generating bank, which transfers convective heat for steam generation. The gases exit the boiler at a temperature of 316° C (600° F). The fuel gas waste heat is recovered in a tubular air heater before entering the dust collector unit. The dust collector is a mechanical multi-cyclone collector manufactured by Air Correction, U.O.P. Inc. The centrifugal action of the gas passing through the collector tubes separates the solid particles, such as dust and ash, from the gas streams. The cleaner gases leaving the collector enter the inlet of the induced draft fan, which controls the furnace pressure automatically to the desired set point. The combustion gases are then directed into the existing plant stack for discharge to the environment.

Wood ash and fly ash are removed from four collection points (the furnace grate, generating bank hoppers, air heater hopper and the dust collector unit) and are transported by screw conveyors to enclosed bins which are emptied at the landfill site.



Addition of wood-fired boiler
University of New Brunswick



University of New Brunswick central heating plant. Steam production for first year of operation (by month).

Economic Analysis:

Project Capital Costs (including interest during construction):

Site works	$ 420,500
Machinery & equipment	$ 446,000
Wood boiler and auxiliaries	$1,384,000
Instrumentation and controls	$ 118,000
Piping and valving	$ 9,500
Electrical work	$ 42,000
	$2,420,000

Annual Operating and Maintenance Costs (preliminary)

• Value of displaced oil (7.05 million L)	$1,800,000
• Cost of steam from wood plus extra operating and maintenance costs	($ 980,000)
Operating Savings:	$ 820,000

Simple Payback Period: 3 years.

Under the innovative financing scheme, the University retains a portion of the annual savings and provides the remainder to Northeast Energy Services to cover operating, maintenance, training, technical services and support, debt repayment, administration and profit over a 9-year period.

Availability:

- The entire system was custom designed and installed by Northeast Energy Services Limited with ADI Limited of Fredericton acting as consulting engineers.
- The boiler (the largest central heating wood boiler east of Montreal) was built to specifications by Babcock-Wilcox Canada Ltd.
- Northeast provided an intensive one-month training program for operating and maintenance staff as well as start-up supervision for the project.
- The long-term wood fuel supply contract was provided by Northeast as part of the "turnkey" development agreement.
- Technical and operating assistance is provided by Northeast Energy Services Ltd. for 9 years as part of the "turnkey" arrangement.

Similar design and build services may be available across Canada. Experience with large wood-fired systems will be an important element in selecting a contractor.

Further Information:

Further information on the system and a copy of the final technical report are available from:

- ENEROPTIONS
  Energy Secretariat
  Government of New Brunswick
  P.O. Box 6000
  Fredericton, New Brunswick
  E3B 5H1
  (506) 453-3897

Further information is also available from the demonstration project manager:

- Northeast Energy Services Ltd.
  (re: ENEROPTIONS)
  1115 Regent Street
  P.O. Box 44, Station A
  Fredericton, New Brunswick
  E3B 4Y2
  (506) 452-9011

Residential Surface Water Source Heat Pump

NEW BRUNSWICK

Technology:
Heat recovery using surface water source heat pumps

Demonstration Project Manager:
Energy Secretariat
Government of New Brunswick
P.O. Box 6000
Fredericton, New Brunswick
E3B 5H1
(506) 453-3897

Locations:
Douglas Residence, Hillsborough, New Brunswick
Flewelling Residence, Saint John, New Brunswick

Annual Savings: $810 to $3,278
63% - 72% compared to oil-fired heating

Payback Period: 3.9 to 13.4 years

Applicable To:
Residences having access to rivers, lakes or ponds and requiring some or all of:

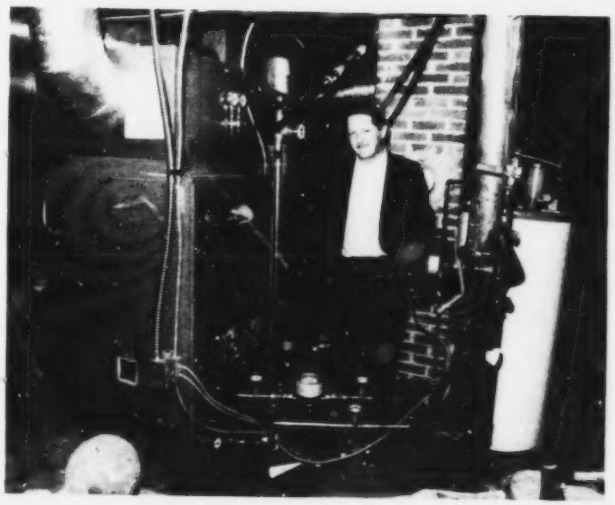
- Space heating
- Air conditioning
- Domestic hot water
- Swimming pool heating

Description:
New Brunswick homeowners, with close access to rivers, lakes and ponds, are finding that the surface water-sourced heat pump can be a money-saving alternative technology for space heating and air conditioning.

At the Douglas residence in Hillsborough, New Brunswick, water is pumped directly from an adjacent pond to two heat pumps. Heat is extracted from this water and used to supply space heating and to supplement domestic hot water requirements.

Energy extracted from the Saint John River is used to produce heat for space heating and to preheat the domestic water supply of the Flewelling family. Coils, placed in the Saint John River adjacent to the residence, contain a glycol solution which is circulated between these coils and a heat pump.

A similar river source heat pump at another location is used for winter heating and domestic hot water pre-heating. In the summer air conditioning mode, heat is extracted from the house and used to heat a swimming pool.



Benefits:

- Annual savings at the Douglas residence are $3,278 or 72% while Mr. M. Flewelling reduces his energy costs by 63% or $810 annually.
- Heat pumps can supply space heating requirements, can contribute to domestic hot water pre-heating, and can, as well, provide summer air conditioning.

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Performance:

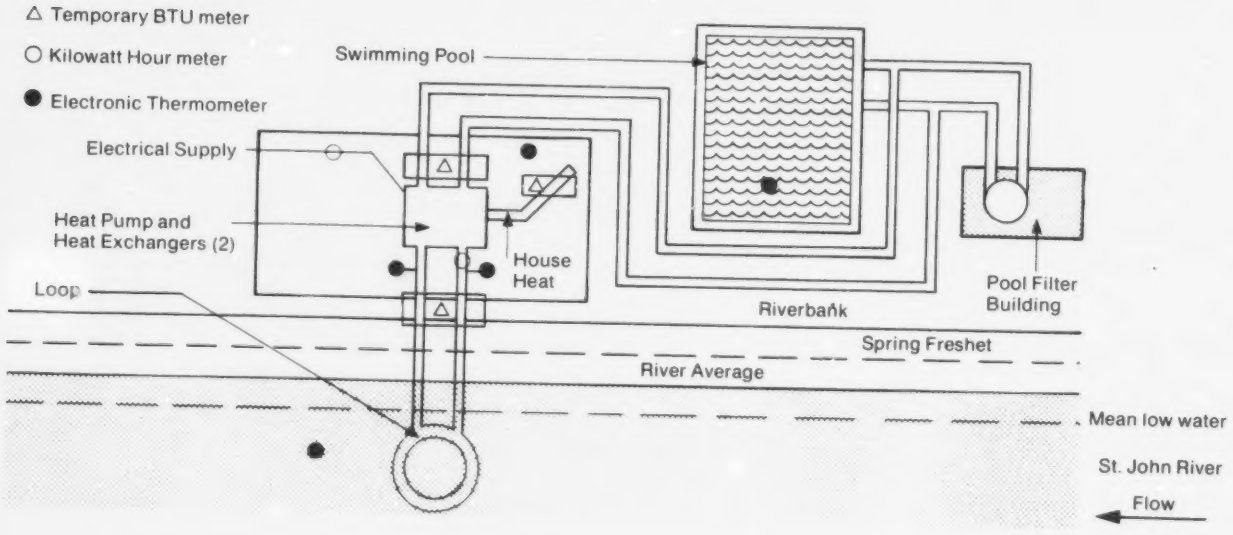
- The seasonal coefficient of performance (COP = heat pump energy output divided by energy input) at the Douglas residence was 2.93. A COP of 2.11 was attained at the Flewelling residence.
- The seasonal performance factors (total energy output divided by total energy input, including water pumping) at the Douglas and Flewelling residences were 2.27 and 1.78, respectively.
- The temperature of the water or glycol solution at the inlet to the heat pump has an important bearing on performance. The coefficient of performance generally dropped below 2.0 when this fluid temperature fell below O° C (32° F).

Technical Details:

Two water source heat pumps are installed in the 372 m² (4,000 ft²) two-storey residence of Mr. N. Douglas of Hillsborough, New Brunswick.

Water is pumped from a pond on the property to two 15.2 kW Aquatec 52 Hu heat pumps. Heat is extracted from this water, and is returned to the pond. Both heat pump units contribute to the space heating of the residence, while one of the units also contributes to the heating of domestic hot water.

The 188 m² (2,024 ft²) Flewelling residence in Saint John, New Brunswick, is heated with a 11.7 kW Maritime Geothermal (formally Glencar) water source heat pump. The unit also preheats domestic hot water. Three hundred metres (984 ft) of 38 mm (1.5 in) PVC pipe have been placed on the bottom of the Saint John River. A 50/50 solution of ethylene-glycol and water is pumped between this collector loop and the heat pump to extract heat from the river. The temperature of the glycol solution at the inlet to the heat pump varies between -4.5° C (24° F) and 14° C (57° F) over the course of the year. The extraction of heat from this fluid lowers its temperature by 2 to 4° C (3.6 to 7.2° F).



Economic Analysis:

In general, the replacement of existing heating systems with water source heat pumps cannot be justified on the basis of energy savings alone. In certain situations, they can provide a viable alternative for new buildings or where the existing system requires replacement.

Some of the factors that affect the viability of this space conditioning approach include:

- The temperature of the surface water
- The elevation between the water source and the heat pump
- The space conditioning load of the building
- Local climatic conditions, and
- Local energy prices for oil and electricity

The following provides the costs, savings and payback periods associated with these demonstration projects:

Location	System Total Cost ($)	Assumed Cost[1] of Conv. Syst. ($)	Incremental[2] Cost of H.P. System ($)
Douglas Residence	12,700	6,664	6,036
Flewelling Residence	10,834	3,356	7,478

Location	Energy Cost[3] Savings ($/yr)	Payback Total[4] (yrs)	Payback Incremental[5] (yrs)
Douglas Residence	3,278	3.9	1.8
Flewelling Residence	810	13.4	9.2

(1) Conventional system assumed to be oil-fired.

(2) Difference between heat pump system and assumed cost of conventional system.

(3) Based on electricity price of $0.427 /kWh and oil price of $0.39 /L

(4) System total cost divided by energy cost savings.

(5) Incremental cost of the heat pump system divided by energy cost savings.

Availability:

Heat pumps for use with surface water sources are available from a number of manufacturers. Care should be taken to ensure that the unit selected is designed to accommodate variations in local water temperatures.

Further Information:

Further information and a copy of the monitoring report on these projects is available from:

- ENEROPTIONS
  Energy Secretariat
  Government of New Brunswick
  P.O. Box 6000
  Fredericton, New Brunswick
  E3B 5H1
  (506) 453-3897

Feasibility of a Wood Energy Industry in New Brunswick

Technology:
Economic analyses of the large-scale collection of forest and mill residues, the production of wood-chips, and their usage for residential, commercial and industrial heating.

Demonstration Project Managers:

Detailed Study: Doug Gorman
ADI Limited
1151 Regent Street
Fredericton, New Brunswick
E3B 3Z1

General Study: R.G. McKenna
Neill and Gunter Ltd.
P.O. Box 713
Fredericton, New Brunswick
E3B 5B4

Location:
South-central and eastern New Brunswick

Annual Savings:
Potential fuel savings of 11% to 30%

Payback Period:
Less than two years for firms engaging in the wood fuel supply industry

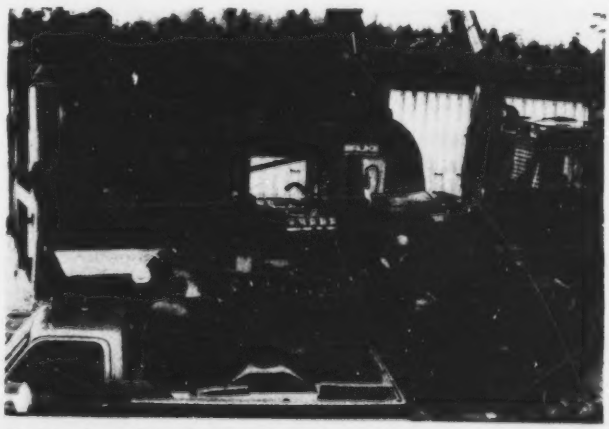
Applicable to:

- Suppliers of roundwood, green wood chips or hogged sawmill residues
- Residential, commercial and institutional buildings and industries currently using oil for heating
- Regions with existing forest industries and large cut-over areas

Description:
These two studies determined the availability of, and markets for, fuelwood in the areas of Kings and Queens Counties in south-central New Brunswick, and in the area around Newcastle in eastern New Brunswick, with the objective of determining whether a wood fuel industry could become viable. Both were feasibility studies and they showed that under a wide range of conditions profitable industries could be developed to sell semi-processed forms of wood fuel into markets located within about 50 km (30 mi) of the source.

The first study considered the supply of logging residues and assessed the potential for establishing various kinds of wood fuel operations that would produce more or less processed forms of fuel. Model industries were "built" on paper and profit statements were developed under varying supply/demand conditions.

The second study began with a detailed on-site survey of logging residues exclusively in a cut-over region, and went on to determine the methods and costs of producing chips from this material. The study also determined heating costs at schools, hospitals and industries of different sizes to determine the price of wood chips at which each would find it advantageous to convert from oil heating.



A side view of the Bruks chipping system.

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Benefits:

- Business opportunities were identified that would yield returns of:
  - 65% per year on an investment of $416,000 for a firm supplying green wood chips;
  - 71% on an investment of $647,000 for a firm supplying hogged sawmill residues;
  - 77% on an investment of $265,000 for a firm supplying roundwood (split or whole).
- Improved rates of return and upgraded operations for firms currently selling merchantable timber.
- More stable operations in the face of varying demand and price levels.
- Displacement of up to 10 million L (2.2 million gals) of oil (light fuel oil equivalents) in Kings and Queens Counties and over 50 million L (11 million gals) of mainly heavy fuel oil in the Miramichi region.
- Employment generation at the site where the residues occur, in trucking them to markets, and at the point of use.
- Simplification of reforestation and reduction of fire hazards through the recovery of forest residues.

Economic Analysis (Kings and Queens Counties):

The Market

Wood fuels can replace oil used for heating. The wood energy market was estimated to be 11% of the existing oil market, or 49,450 bone dry tonnes (54,500 tons) per year. This estimate assumed that sales of residential wood stoves would continue at current rates and that aggressive marketing by the wood energy industry would convince 15% of the industrial/agricultural and 5% of the commercial/institutional users to convert to wood fuel heating.

The maximum price that sellers of wood fuel could charge was determined by calculating the costs to the user that would bring the present values of his or her savings from converting to wood fuel, minus the expenses of conversion, to zero, using interest rates of 15% or 20% and a system life of 10 years.

The Supply

Wood fuel can be obtained from two sources: residues from wood processing mills and biomass from the forest. Within the study area, ten mills were identified as potential sources of 69,433 bone dry tonnes (76,537 tons) per year of residues. The study area is almost completely covered with land classed as productive forest. The estimated recoverable forest biomass from this area is 115,875 bone dry tonnes (127,730 tons) a year. In total, the annual supply of biomass estimated to be available is nearly four times as large as the estimated demand. Production methods to bring this fuelwood from source to consumer could be based on delivery of any of the following products, each of which was modelled:

- green wood chips
- dried (to 20% moisture) wood chips
- hogged sawmill residues
- densified wood pellets
- split or whole roundwood in varying lengths.

Financial Analysis

The financial analysis indicates that green wood-chip, sawmill residue and fuelwood supply businesses are financially viable, but dried chips and pellets are not. The sawmill residue supply business has the highest return on investment of the various models because of the low cost for raw materials.

Each type of firm is sensitive to changes in sales prices for the product, as shown by a substantial increase in return on investment from the low price to the most likely price case study. However, there is a good margin of safety between the most likely sales prices and the minimum sales prices required to produce a 20% return on investment. The sales prices for wood chips, sawmill residues and fuelwood could drop by 18%, 50% and 17% respectively and still give an attractive return on investment. The different firms are much less sensitive to changes in sales volumes. In the most likely case, wood-chip, sawmill residue, and fuelwood sales could decrease by 54%, 64% and 48% respectively and still yield a 20% return on investment.

Economic Analysis (Miramichi Region):

The Market

It was estimated that a market could exist for 241,000 tonnes (265,650 tons) per year of forest residues (80% moisture content dry basis) if it could be delivered at competitive prices. This is far below the amount *physically* available, but not necessarily below the amount *economically* available. The size of the market was based on a survey of oil consumption in the schools, hospitals and industries of the region. These users generally have the high, stable demands that favour the conversion of oil-fired boilers to those capable of burning wood chips. Typical examples of a small school, large school, hospital and large industry were analysed to establish the price of wood chips at which conversion to burn wood fuel becomes economic. (Wood, even at zero cost, was not competitive with oil, for small industries.)

The Supply

Cut-over areas were listed and classified by cover type, cut age and volume. (Cuts older than five years were eliminated because of the decay of the residue.) Representative cuts were visited, and the amount of residue in each was measured by weighing material collected from sample plots. At this stage, four and five year old cuts were also eliminated because the average weight of material per hectare was only half of the 47 tonnes (52 tons) found on one year old cuts. The data showed that 46,875 oven-dry tonnes (51,670 tons) of residue material were available from each 1,000 hectares (2,470 acres) of cutover land. Assuming a harvest of 8,000 hectares (19,765 acres) a year, this would make available 375,000 tonnes (413,366 tons) per year.

Three production methods were examined to determine the cost of producing wood chips:

- the retrieval of branches, tree tops and standing residuals and their transportation to a cental site for chipping as a separate operation from the harvesting of merchantable wood;
- the chipping of branches, tops and trees brought to a cental processing site in conjunction with the harvest of merchantable timber;
- the harvesting of low-grade stands exclusively for fuel.

Using data from a number of sources the cost per km-tonne was calculated to be $7.02 ($7.74 per km-ton). This cost includes all operating and capital costs as well as a 15% profit. It was assumed that the chips would be transported by a 5-axle tractor trailer combination with a total carrying volume of 86.6 m^3 (3,058 ft^3).

Financial Analysis

Wood chips produced in whole-tree harvesting are generally fully competitive with oil, even with quite long truck hauls. However, cutting forest stands exclusively for wood chips is practical only if the users are small schools or if they are industries with existing wood-burning equipment or hospitals within a short distance of the source. Specifically:

- a small school could economically use wood chips produced in conjunction with harvesting merchantable timber or from stands of non-merchantable trees if they are trucked 50 km (30 mi) or less;
- a large school could economically use wood chips produced in conjunction with harvesting merchantable timber if they are trucked 5 km (3 mi) or less due to the assumptions of high capital cost and low load factor;
- a hospital could economically use wood chips produced in conjunction with harvesting merchantable timber if they are trucked 70 km (43 mi) or less or from stands of non-merchantable trees if they are trucked 40 km (25 mi) or less;
- a large industry with a wood-fired boiler in place could economically use wood chips produced in conjunction with the harvesting of merchantable timber if they are trucked 70 km (43 mi) or less.

With conventional methods, chips developed in separate clean-up operations are uneconomic except for small schools and for large industries with existing wood-burning equipment and located within 30 km (18 mi) of the fuel source.

Business and Labour Skills:

The business skills necessary to operate the wood energy industry are similar to those required for any small business. In addition, management personnel would require a thorough knowledge of the various components of the wood energy industry. These skills and knowledge are similar to those employed by sawlog and pulpwood harvesting contractors and sawmill operators.

Because the harvesting and processing of forest products is one of the major industries of New Brunswick, a wood fuel supply business would encounter no difficulties in obtaining the skilled and semi-skilled labour that it needs in that province. Some added training or upgrading will be necessary for oil burner mechanics who are not familiar with the installation and servicing of solid fuel combustion systems.

The wood energy industry could be established as an independent business or as an addition to an existing wood-related enterprise. The latter case is more attractive because it offers savings in overhead costs and improves the utilization of existing manpower and equipment. This is especially true if the new business is initiated by an independent wood-chip contractor operating at less than full capacity because of quota limits established by pulp mills.

Special Problems:

Several special problems must be resolved if barriers are not to arise and limit the development of a wood fuel industry. First, an inventory of wood fuels must be maintained at several points in the wood energy system in order to overcome seasonal differences in fuel supply and demand, to permit orderly and economic deliveries from the supply to the consumer, and to ensure a reliable and adequate supply of wood fuels during unexpected problem periods. The inventory points will be at the consumer, at the fuel processing location, and at the fuel source. Each of these locations will require a fuel storage volume and method which is specific to its function in the system.

Second, consumers who use wood chips and wood residue fuels will require all of the services that owners of an oil-fired furnace would need plus additional services that are particular to solid fuels. Typically, these would include a twice-yearly furnace and flue cleaning, maintenance insurance on the additional mechanical equipment associated with the fuel feeding system, and removal of the furnace ashes from the owner's property, possibly by the fuel supplier.

Third, although studies indicate that environmental impacts associated with the harvesting of residues are small compared with those of the original logging, excessive recovery could rob the soil of needed nutrients.

Finally, there is one area of concern related to the source materials. At present from both the economic and the silvicultural points of view, it would be desirable to develop wood fuel industries based on mill and logging residues. However, before long these residues could come to have higher value as industrial feedstock than as fuel.

Further Information:

For further information and a copy of either of the final reports, contact:

- ENEROPTIONS
  Government of New Brunswick
  P.O. Box 6000
  Fredericton, New Brunswick
  E3B 5H1
  (506) 453-3897

- Doug Gorman
  (re: ENEROPTIONS)
  ADI Limited
  1151 Regent Street
  Fredericton, New Brunswick
  E3B 3Z1
  (506) 454-4491

- R.G. McKenna
  (re: ENEROPTIONS)
  Neill and Gunter Ltd.
  P.O. Box 713
  Fredericton, New Brunswick
  E3B 5B4
  (506) 452-7000

Harvesting Forest Residue

REPAP MIRAMICHI FOREST PRODUCTS

Technology:
Combining the harvesting of pulpwood and non-commercial or below-grade timber.

Demonstration Project Manager:
Mr. Jan Ellingsen
Repap Miramichi Forest Products
P.O. Box 5040
Newcastle, New Brunswick
E1V 3N3

Location:
Newcastle, New Brunswick

Annual Savings: $190,240
$23.78 per tonne of wood chips used plus $13,500 in site preparation costs

Payback Period: 1.2 years

Applicable to: Forest products industries

Description:
By integrating the harvesting of pulpwood and non-commercial timber, the Repap Miramichi Forest Products (formerly Boise Cascade Canada Ltd.) pulp and paper mill at Newcastle, N.B., was able to clear-cut and replant a tract of forest that would not otherwise have been economical to cut at all. This was achieved because of both added revenues from the hog fuel provided by the wood residues and reduced costs from savings in site preparation for reforestation.

On a 135 hectare (334 acre) tract located 16 km (10 mi) from the pulpmill, the merchantable trees were cut and delivered to the pulpmill and local sawmills. The remaining trees were then felled, and a mobile chipper was brought in to process the trees and other logging residues. To maximize productivity, chipping took place at the roadside where a brush forwarder had collected the wood into piles. The chipped material was trucked to the mill to be burnt. The harvest site was then planted with softwood which will provide a higher yield in a shorter time and without additional site preparation costs.

Repap Miramichi has continued to use integrated harvesting and is pleased with the results.

Benefits:

- Use of forest residues in the form of chips replaced 500,000 litres (110,000 gals) of Bunker C oil, resulting in a cost savings of $190,240 or $23.78 per tonne ($21.57 per ton) of wood chips.
- Savings of $13,500 ($100 per hectare) were realized in the cost of preparing the site to be replanted with high quality softwoods.
- Eleven permanent jobs were created in connection with harvesting, chipping and transportation.
- Wood costs for the pulp and paper mill have been minimized by the harvesting of high quality pulpwood close to the mill. Planting of new trees will ensure a continued supply of good quality, low-cost wood close to the mill.
- Maximum use of soil capacity with respect to harvesting of available biomass.

ENERGOPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENERGOPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Performance:

Over a period of 8 months, 135 hectares (334 acres) of low-volume stands were cleared with a yield of 8,000 tonnes (8,818 tons) of hog fuel and 6,539 m^3 solid (230,900 ft^3) of pulpwood and sawlogs. Total marketable volume per hectare was 48.43 m^3 solid (1,710 ft^3) and hog fuel volume was 59.3 tonnes (65 tons) per hectare. Utilization of biomass was high with 93.6% of total available material being removed.

Productivity of the operation was affected by a number of factors. Proper directional felling of unmerchantable species was important to simplify the work of the chipper. A forwarder was used to collect felled trees in areas of low ground strength so the chipper would not get stuck. Use of the forwarder improved the overall productivity of the system.

Proper coordination of the trucking of wood chips with the chipper necessitated the development of a system of containers to store the chips between loads.

Moisture content in the wood had a significant effect on the chipper's productivity. In general, for a given species, the higher the moisture content the lower the productivity.

Technical Details:

Repap Miramichi Forest Products operates a 200,000 T.P.Y. kraft pulpmill in Newcastle, N.B. There are approximately 1,700 hectares (4,200 acres) of Crown land leased to the company within a 25 km (16 mi) radius of the mill. Much of this forest is of poor quality although it would have a high production capacity if properly planted; that is, the soil growth capacity is not being utilized at present.

The site chosen for the project was located 16 km (10 mi) from the mill. Using a manual shortwood system, all merchantable softwood trees were harvested. The remaining trees (i.e., trembling aspen, beech and maple) were directionally felled to facilitate processing by the chipper.

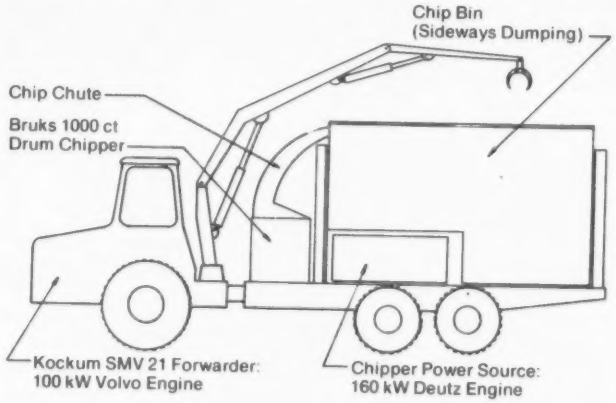
The chip harvester consists of a chipping unit, a 200 hp air-cooled Deutz diesel engine and a 17 m^3 (600 ft^3) chip bin mounted on a Kockum SMV21 forwarder chassis. The chipper, manufactured by Bruks Medaniska AB in Sweden, is a horizontally-fed drum unit which has a maximum tree diameter capacity of 40 cm (16 in). A loader mounted on the front chassis of the forwarder feeds the wood into the chipper's two hydraulically-driven feed rollers.

When the chip bin is full, the chipper travels to roadside and hydraulically lifts and tilts its load into a truck or container.

During the last nine weeks of the project, a brush forwarder was used in conjunction with the chipper. The forwarder was a Tree Farmer C6D with a 4.8 m (16 ft) bed and a bypass grapple. Although the load stakes were extended both horizontally and vertically to accommodate the largest possible load, the larger trees still had to be cut to 6 m (20 ft) lengths.

When the forwarder was in operation, the chipper would alternate between processing the wood the forwarder brought to roadside and working in the bush. A single truck was used to transport the wood chips to the mill. It was a tandem drive Ford, Model LT800 with a 34 m^3 (1,200 ft^3) dump box which could accommodate two full loads of the chip harvester. A subsequent project tested a system using 6 containers and a Hiab-Foca Svenska Forsaljnings AB model LV316 Load Exchanger which, by the addition of a trailer, could carry 2 containers at a time. This system lowered transportation costs and eliminated bottlenecks.

A total crew of 11 people was required to run the operation, although all are not continuously employed.



Integrated Chip Harvester

Economic Analysis:

Fuel Savings:

- Cost of producing 8,000 tonnes of wood chips is $233,780
- Cost of wood chips is $\frac{\$233,780}{8,000} = \$29.22$/tonne
- Value of oil displaced is 1.52 × $34.86 = $53.00/tonne*
- Thus, fuel savings are $53.00 – $29.22 = $23.78/tonne or $23.78 × 8,000 = $190,240 in total

*– 1 tonne of wood chips is the equivalent of 1.52 barrels of oil – assumes cost of oil at $34.86 per barrel

Payback Period:

- Cost: $233,780
- Savings: $190,240 per year
- Payback period: 1.2 years

Other Savings:

- Savings in site preparation costs estimated @ $100/ha Thus 135 ha × $100 = $13,500
- Use of a container system for transportation reduced the cost per tonne by $3.00 to $26.22

Availability:

Integrated harvesting uses equipment available across the country.

The Bruks chipper was supplied by:

BDR Machinery
1104 Feuster Ave.
Mississauga, Ontario
L4W 2V7

Further Information:

For further information and a copy of the technical report, contact:

- ENEROPTIONS
  Energy Secretariat
  Government of New Brunswick
  P.O. Box 6000
  Fredericton, New Brunswick
  E3B 5H1
  (506) 453-3897

- Jan Ellingsen
  (re: ENEROPTIONS)
  Repap Miramichi Forest Products
  P.O. Box 5040
  Newcastle, New Brunswick
  E1V 3N3
  (506) 622-2250

ENERGOPTIONS CASE STUDY

NFLD 3

Wood-Fired Boiler

JAMES PATON MEMORIAL HOSPITAL

Technology:
Large-scale, direct combustion of wood residues

Demonstration Project Manager:
Peter Lush, Chief Engineer
James Paton Memorial Hospital
Trans-Canada Highway
Gander, Newfoundland
A1V 1P7
(709) 651-2500

Location:
Gander, Newfoundland

Annual Savings: $100,000
More than 38% of conventional operating costs

Payback Period: 10 years

Applicable to:
- Hospitals
- Nursing homes
- Universities
- Schools
- Remote communities
- Large industries in areas where there is a secure supply of wood residues.

Description:
The James Paton Memorial Hospital, a 19 year-old, 162-bed institution with a heated area of 11,900 m^2 (128,000 ft^2) has reduced both its annual heating bill and its energy consumption by replacing its old oil-fired boilers with a wood-fired Canadian Wet Cell burner. By switching from Bunker C oil to wood residue as a heating fuel, the hospital is not only saving $100,000 per year but has also created local employment. The hospital has hired a contractor to collect wood residue from pulp log harvesting, chip it and deliver the chips to the hospital. The money spent on fuel, which previously left the community, now remains within the local area, which in turn creates further employment. The system has been operational since April 1983 with no equipment-related or other problems.

Benefits:
- Savings resulting from the displacement of Bunker C oil with wood residue have been approximately $100,000 per year.
- The switch to wood has brought about a noticeable reduction in sulphur emissions.
- Two permanent jobs have been created in connection with the harvesting, chipping and delivery of the wood.

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Performance:

The viability of burning wood to produce steam for heating has been demonstrated by this project. The wood-burner operates at an efficiency of 65%. With respect to reliability and maintenance requirements, the system is operating above expectations.

Some problems were experienced with contamination of the wood chips by dirt and rocks. These caused damage to the fuel-loading system and an excessive amount of clinker in the ash. The contamination, which was caused by storing the chips on the ground, disappeared when this practice was stopped. There have been no problems with wood truck noise or with ash disposal.

While maintenance cost figures are not yet available, experience to date indicates that costs will likely be comparable to those associated with an oil system.

Technical Details:

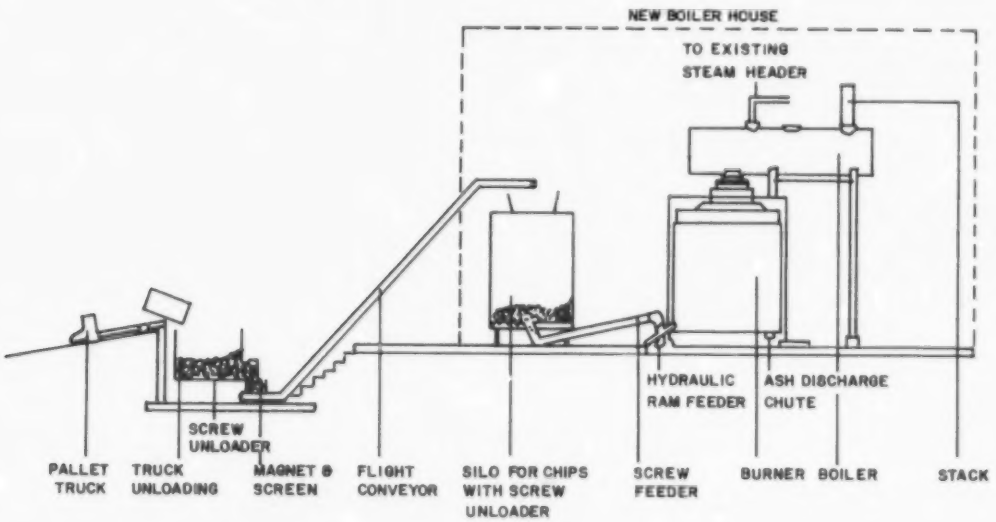
Prior to the installation of the wood-burning system, the steam supply of the hospital was produced by two 250 hp Powermaster oil-fired steam boilers. They normally operated at an output of between 1,360 to 2,720 kg steam per hour (3,000 - 6,000 lbs/hr) at 690 kPa (100 psi) and 164° C (327° F).

The burner selected for the project was a Canadian-designed 1.8 MW Lamb Cargate Wet Cell burner, the most efficient but also the most expensive of the units considered. The burner was housed in an extension built on the boiler house to protect it from the harshness of the Newfoundland environment, specifically high relative humidity and high salt content in the air.

The wood chips are supplied to the hospital by Central Forest Products. Waste logs are collected from pulp mills, chipped using a Morbark Eager Beaver Chipper and delivered to the hospital by truck.

When the wood chips are delivered they are dumped into an unloading hopper and moved by screw-type conveyors to a 5 cm (2 in) mesh vibrating screen. Once through the screen, the chips pass by a magnet, (which removes metal objects) and are loaded into a 50,650 cm^3 (3,091 in^3) storage silo. The silo holds enough chips to fire the burner for two days.

The chips are then moved by a sweep auger in the silo into a discharge hopper, which feeds them into a variable speed screw to be loaded into a ram feeder. The mechanism to transport the chips from the silo to the burner was supplied by Laidig Inc. The feed screw and the ram feeder, which push the chips into the bottom of the burner, are controlled by the burner combustion control system. The ashes are discharged by a conveyor to barrels located outside the boiler house.



Material flow diagram for James Paton Memorial Hospital, Gander, Nfld.

Economic Analysis:

Capital Cost Summary

Equipment (loading devices, burner/boiler unit, chipper, etc.)	$421,460
Other (boiler house extension, installation burner/boiler installation loading devices, etc.)	$586,540
Total	$1,008,000

Annual Operating Cost Savings

Oil-fired system cost	$260,000
Wood-fired system cost	($160,000)
Savings	$100,000

Payback Period $\frac{\$1,008,000}{\$100,000} = 10$ years

NOTE: The payback period was longer than expected because the most expensive burner was chosen and cost overruns resulted from lack of experience with this type of installation.

Availability:

The burner was supplied by:
Lamb Cargate
P.O. Box 440
1135 Queens Ave.
New Westminster, B.C.
V3L 4Y7

The silo unloading system was supplied by:
Laidig Inc.
1320 South Merrifield
Mishawaha, Indiana 46544
U.S.A.

The chipper was supplied by:
Morbark Industries
P.O. Box 1000
Winn, Michigan 48896
U.S.A.

The chips were supplied by:
Central Forest Products
247 Elizabeth Drive
Gander, Newfoundland
A1V 1J3

Further Information:

For further information and a copy of the final technical report, contact:

- Energy Branch
  Department of Mines and Energy
  Government of Newfoundland and Labrador
  P.O. Box 4750
  St. John's, Newfoundland
  A1C 5T7
  (709) 576-2411

The project manager and system owner is:

- Peter Lush, Chief Engineer
  (re: ENEROPTIONS)
  James Paton Memorial Hospital
  Trans-Canada Highway
  Gander, Newfoundland
  A1V 1P7
  (709) 651-2500

Whole Tree Chipping for Fuel

ABITIBI-PRICE PULP & PAPER MILL—NFLD.

Technology:
Harvesting, chipping, delivery and burning of hardwood.

Demonstration Project Manager:
Harvey G. Taylor
Production Superintendent
Abitibi-Price Pulp & Paper Mill
P.O. Box 500
Grand Falls, Newfoundland
A2A 2K1

Location:
Grand Falls, Newfoundland

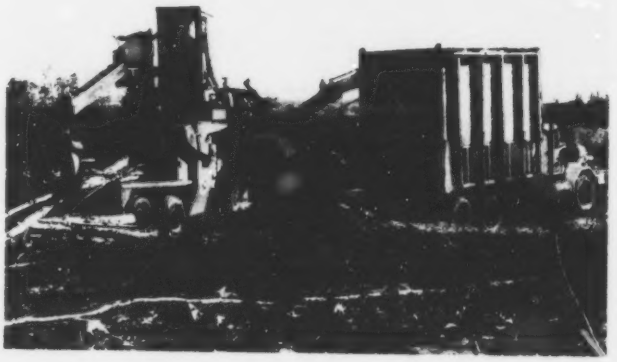
Annual Savings: $187,400
(based on projection from 24 weeks operation) or $5.92 for each tonne of wood chips used.

Payback Period: 4.5 years

Applicable to:
Forest sector industries

Description:
This project evaluated a complete harvesting-chipping-transportation system for the burning of hardwoods for fuel as an alternative to Bunker C oil at the Abitibi-Price Pulp and Paper Mill in Grand Falls, Newfoundland. The trees in a nearby stand were felled manually and were hauled to a central landing by choker-rigged wheeled skidders. There they were chipped and loaded into modified dump trucks and tractor trailer vans for delivery to the newsprint mill.

The project resulted in an energy cost saving of $5.92/tonne ($5.37/ton) of wood chips and identified additional opportunities for system modification that could further increase cost savings in future operations.



Benefits:

- Energy costs were reduced by $86,491
- 13 jobs were created
- 16,071 barrels of oil were replaced by 14,610 tonnes (16,105 tons) of locally harvested wood chips.

Performance:

In 24 weeks of operation (7 days/week) the project produced 14,610 tonnes (16,105 tons) of chips, at a rate of 87 tonnes/day (96 tons/day) and a cost of $26.64 per tonne ($24.17/ton). When manual felling was replaced by a Hydro-AX feller-buncher the cost per tonne dropped but not enough to justify the extra cost of the equipment.

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Although the operation was profitable, the project manager concluded that a number of improvements could still be made. The use of choker skidders should be reconsidered because the mud and dirt which the trees accumulated as they were dragged along the ground by the skidders resulted in breakdowns of the chipper. The trucking system, which was responsible for 15% of the system's downtime, should be improved by the addition of a chip-van dumper at the mill.

Technical Details:

The harvesting took place in a 400 hectare (988 acre) hardwood stand composed mainly of white birch situated on slightly rolling terrain about 3 km (1.9 mi) from the mill. The average mean diameter of the harvested trees was 9.3 cm (3.7 in), well below merchantable size for pulpwood.

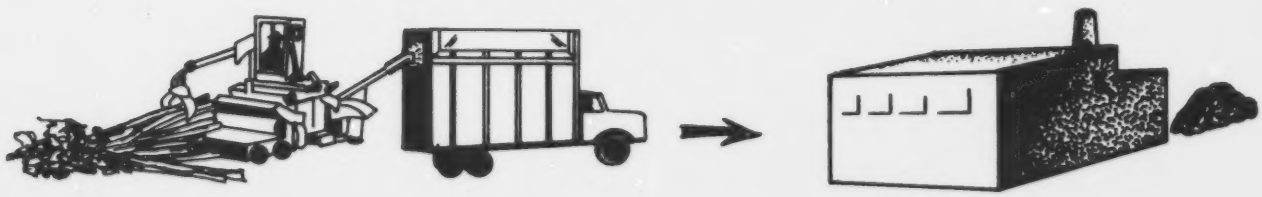
The project ran for 24 weeks, from June 29 to December 11, 1982. The equipment used was:

- A Morbark 22RXL total chip harvester with a Barko 160 hydraulic loader
- Three modified tandem dump trucks (White)
- Six choker wheeled skidders (Timberjack 230)
- Five Jonesered chainsaws
- One Hydro-Ax Model 411 B feller buncher

A crew of 13 worked on the project.

The chipper had to be modified by extending the main drive shaft and using a pillow block bearing to take the strain. This eliminated shaft and clutch breakages.

Mature birch stands — Manual felling — Cable skidding to roadside



Chipping into trucks — Stockpile at the mill

Economic Analysis:

Over a 24-week period:

- Cost of producing 14,610 tonnes (16,105 tons) of wood chips is $389,210
- Cost of wood chips is $\frac{\$389,210}{14,610}$ = 26.64/tonne
- Value of oil displaced is 1.1 × $29.60 = $32.56/tonne*
- Thus, fuel savings are $32.56 - $26.64 = $5.92/tonne or $5.92 × 14,610 = $86,491 in total

*- 1 tonne of wood chips is the equivalent of 1.1 barrels of oil

- assumes an oil cost of $29.60 per barrel

Payback:

Cost: $389,210

Savings: $86,491

Payback Period: 4.5 years.

Availability:

The chipper was supplied by:
Morbark Industries
Box 1000
Winn, Michigan 48896
U.S.A.

Similar equipment is available across Canada.

Further Information:

For further information and a copy of the final technical report contact:

- ENEROPTIONS
  Department of Mines and Energy
  Government of Newfoundland and Labrador
  P.O. Box 4750
  St. John's, Newfoundland
  A1C 5T7
  (709) 737-2411

- Harvey G. Taylor
  (re: ENEROPTIONS)
  Production Superintendent
  Abitibi-Price Pulp & Paper Mill
  P.O. Box 500
  Grand Falls, Newfoundland
  A2A 2K1
  (709) 489-2201

Fish Dryer Heat Pump Conversion

H.B. DAWE LTD. — CUPIDS, NEWFOUNDLAND

Technology:
Recirculating heat pump dryer system

Demonstration Project Manager:
Canadian Saltfish Corporation
P.O. Box 6088
St. John's, Newfoundland
A1C 5X8

Location:
Cupids, Newfoundland

Annual Savings: $24,800
43% saving in cost of drying fish

Payback Period: 7½ years

Applicable to:
Fish processing plants using single-pass oil or gas-fired drying equipment.

Description:

A recirculating heat pump system is used to replace a single-pass oil-fired fish dryer at the Canadian Saltfish Corporation's H.B. Dawe fish processing plant at Cupids, Newfoundland.

The heat pump recovers heat and removes moisture from downstream air and then warms the dehumidified air for re-use in the drying process.

This closed loop system operates independently of outside air conditions. Compared with a single-pass oil-fired or gas-fired dryer, the heat pump system reduces energy costs and allows higher drying rates during humid weather conditions.

Benefits:

- The cost of energy for fish drying is reduced significantly. The quality of the dried fish product is improved.
- The drying rate is independent of outside air humidity, thus allowing summer operation. This results in extended employment and higher productivity and profits.

Performance:

The heat pump drying system has been operating successfully for 2½ years. The cost of drying fish using the new system has proven to be $0.031/kg compared with $0.055/kg for the single-pass oil-fired system — a saving of 43% per unit.

A number of start-up problems were experienced but these were quickly rectified as the installer/designer and operating personnel became more familiar with the equipment and its control systems.

Technical Details:

The conventional oil-fired fish dryer which was replaced in this project consisted of a drying tunnel through which warm air was forced by a fan. The air was heated by an oil-fired furnace. There was some recirculation of moist air back to the warm end of the tunnel, the amount being controlled by a damper in the exhaust duct. The amount of air recirculated was not large, however, and large volumes of makeup air were required. In summer, when makeup air was very humid, the rate of drying was curtailed or stopped.

The heat pump system is designed to be totally independent of outside conditions. The moist warm air leaving the drying tunnel is cooled and dehumidified by the refrigerant evaporator of the heat pump. The air is then re-warmed — by the

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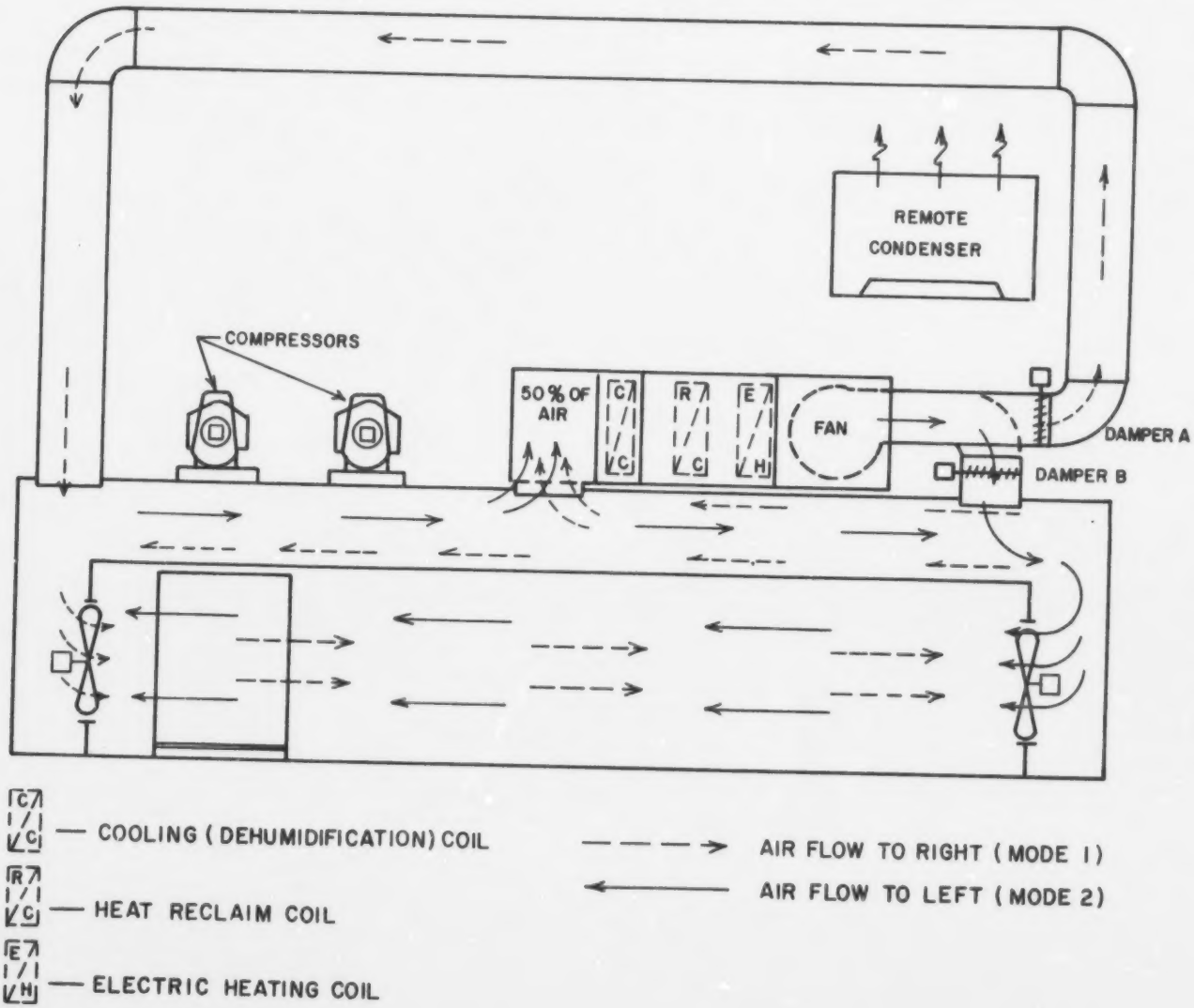
hot, compressed refrigerant in a reclaim coil — before re-use in the dryer. Excess heat generated by the heat pump compressors and dehumidification process is ejected to the atmosphere by a remote air-cooled condenser. Because no makeup air is required in this design, drying can continue at the rated capacity of the dryer even in humid weather. Energy efficiency is also improved. The only losses in the heat pump system are through the remote condenser and these could be recovered for water heating if desired. In the single-pass system, energy was lost in the furnace through combustion products and in the exhausted moist air.

The heat pump dryer was designed and installed in June 1982 by Newton Engineering Ltd. of St. John's, Newfoundland. The system uses Prescold compressors, Keeprite condensers and heat exchangers, and Greenatck fans. Controls were supplied by Controls and Equipment Ltd. of St. John's.

The dryer has a capacity of 5,400 kg (16 carts) of wet, light-salted fish. It is constructed of concrete block walls, a wood frame roof, and rigid insulation covered with plywood. The heat pump is powered by two 50 hp compressors. The main air supply to the drying tunnel is provided by two reversible propeller fans. The air flow across the fish is reversed every few hours. The heat pump system is designed to condition about half of the air passing over the fish — the rest being recirculated unconditioned.

The closed nature of the heat pump system allows operation throughout the summer when high outside humidity levels would have stopped or slowed down a conventional dryer. This extra production could amount to 80,000 kg (176,000 lbs) of finished product per year and is a significant factor in the economic viability of the heat pump system.



Heat Pump Fish Dryer

Economic Analysis:

Capital Costs

General contract including dryer construction, equipment installation design and engineering	$30,000
Mechanical contract including compressors, air-handling equipment, fans, condenser, piping, valves, controls, etc.	$112,970
Electrical contract including new service entrance, wiring and controls	$41,000
Total:	$183,970

Annual Operating Savings and Earnings

Reduced drying cost: 47,000 kg/mo. @ $0.024/kg	$13,600
Value of increased summer production: 80,000 kg @ $0.14/kg profit margin	$11,200
Total Savings and Earnings:	$24,800

Simple Payback Period: 7½ years.

The economics of replacing a conventional dryer with a new dryer based on the heat pump system cannot be justified on energy savings alone. Without the increased production in summer, when the heat pump dryer can operate at full capacity even in humid conditions, the payback period would be over 13 years. The heat pump dryer should therefore only be considered if there is a year-round supply of fish.

The high capital cost of the heat pump dryer also makes it attractive only when an existing dryer is ready for replacement.

Availability:

No special equipment was required in the construction or installation of the heat pump dryer. The unit was designed by Newton Engineering Ltd. of St. John's. Similar designs may be available from other consulting engineers. Fish processing companies that do not maintain specialized in-house engineering departments may wish to retain the services of a qualified engineering firm to handle design, acquisition, installation, and commissioning of this type of equipment.

Further Information:

Further information and a technical report on this project is available from:

- ENEROPTIONS
  Energy Branch
  Department of Mines and Energy
  Government of Newfoundland and Labrador
  St. John's, Newfoundland
  A1C 5T7
  (709) 576-2411

Further information is also available from:

- Newton Engineering Ltd.
  (Re: ENEROPTIONS)
  P.O. Box 4385
  St. John's, Newfoundland
  A1C 5T7
  (709) 722-8613
- B.K. Kennedy
  (Re: ENEROPTIONS)
  Canadian Saltfish Corporation
  P.O. Box 6088
  St. John's, Newfoundland
  A1C 5X8
  (709) 772-6080

Fuelwood Supply Evaluation

BONAVISTA PENINSULA, NEWFOUNDLAND

Technology:
A study of feasibility of establishing a wood fuel supply business

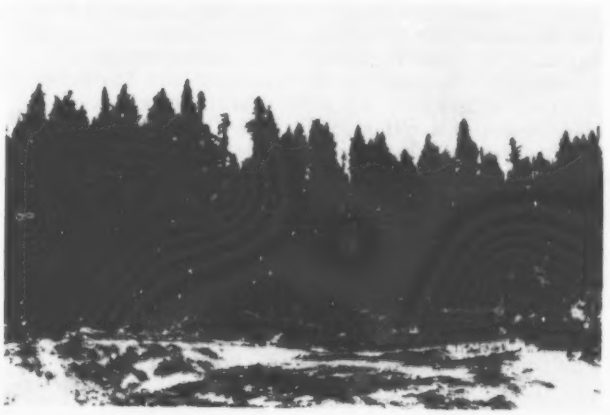
Demonstration Project Managers:
G. Veitch, W. Strong
Highlands Contracting Ltd.
P.O. Box 446
Gander, Newfoundland
A1V 1W8
(709) 651-3748

Location:
Bonavista Peninsula, Newfoundland

Annual Savings: 2.7 million litres (600,000 gallons) of fuel oil

Applicable to: Any area with fuel grade timber or sawmill waste and demand for heat.

Description:
An adequate and continuing supply of wood is essential in establishing a wood fuel supply business. This study reviews the situation in Newfoundland's Bonavista Peninsula to demonstrate how to assess the supply of wood from forests and sawmills and the cost of producing, delivering and storing wood chips for nearby markets. The study concluded that the projected demand for wood chips in the Bonavista Peninsula region is 15,000 green tonnes (16,535 tons) of chips per year, which would replace about 2.7 million L (600,000 gals) of oil (mainly light fuel oil used in commercial and industrial boilers). About 2,000 tonnes (2,200 tons) of chips would come from mill residues and the remainder from harvesting trees that are not otherwise merchantable. The rate of production from the forest is well below annual growth, so the harvest could continue in perpetuity. Average delivered costs would be $27.40 per green tonne ($24.85 per ton) or $49.81 per oven dried tonne ($45.18 per ton).



Benefits:
- 2.7 million L (600,000 gals) of fuel oil displaced by 15,000 green tonnes (16,535 tons) of chips per year. (About 25% of the biomass harvest would occur in the winter when unemployment is highest.);
- The creation of 12 new jobs;
- An increase in revenue to planer mill operations, which would increase the job security of workers at those mills.

ENEROPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENEROPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Method of Determining Supply:

The study began with an assessment of two potential fuelwood sources: mill residues and forest biomass. Mill residues are based on the lumber industry, which is the major user of the forests in the study area. There are over 500 licensed sawmills but only 40 produce more than 50,000 fbm per year, and they are dispersed throughout the region. Most of the residue from the sawmills is in the form of slabs and is already fully used for firewood close to the mills. However, planer mills in the area are concentrated around Goose Bay, and have an accumulated stock of clean residue amounting to 2,000 green tonnes (2,200 tons) which could be immediately chipped for fuelwood. In subsequent years, 1,000 to 2,000 tonnes (1,100 to 2,200 tons) could be chipped provided mill operators are willing to maintain clean stockpiles of residue unmixed with dirt and debris.

In selecting forest stands suitable for chipping, criteria had to be developed to minimize the loss of commercial sawlog and pulpwood stands to fuelwood harvesting. Apart from conventional criteria, such as accessibility, chipping should be considered as a use only for:

- Stands from which the merchantable component had been removed;
- Hardwood stands outside the hauling range of domestic cutters;
- Dense submerchantable softwood (rail type) stands in the mature to over mature age class;
- Damaged stands with no significant sawlog materials;
- Stands identified as existing or potential sources of domestic firewood.

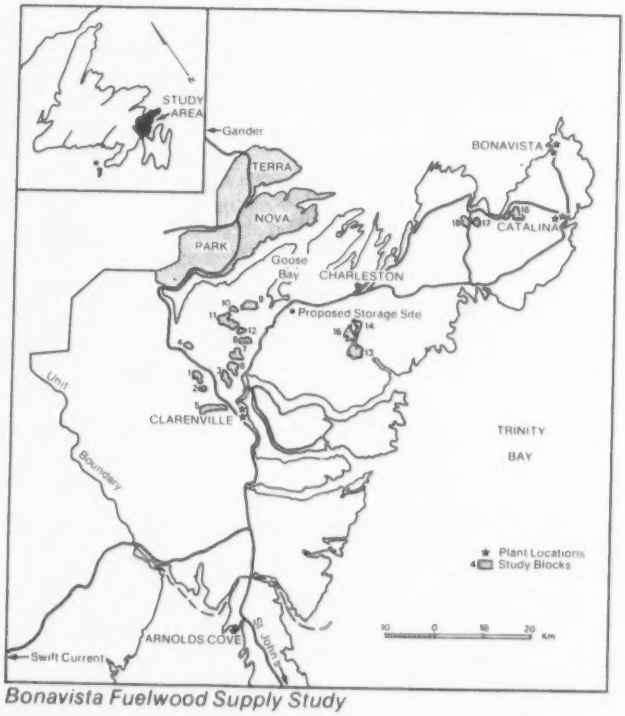
Using 1:30,000 forest type maps and the assistance of the management unit foresters, the stands were chosen, grouped into harvesting blocks and a haulroad network was identified. Only stands within an average hauling distance of 450 m (1,500 ft) from an existing roadside landing were considered, and those areas close to servicing roads (which are normally heavily picked over) were also excluded. Field checks were made to confirm the map data. For that portion of each stand identified for potential chipping, the following were determined:

- Average recoverable mass per unit area;
- Proportion of area recommended for integrated harvesting;
- Average mass recoverable per kilometre of new haul road.

The terrain, accessibility and location of each block were also assessed. Normally, the nature and location of the specific markets for chips would also enter into the final selection of harvesting areas, but, because this information was not available, the production plan was developed by concentrating harvesting over as limited an area as possible and by selecting sites which gave the best overall return.

Technical Details:

A review of possible production systems for the 12,000 to 13,000 green tonnes (13,200 to 14,300 tons) required from forest biomass indicated that central processing, which is capital intensive and provides little employment, was inappropriate for conditions in Newfoundland. Terrain chipping, widely used in Scandinavia but still unproven in Newfoundland, might be appropriate if tests prove successful. The remaining methods all involved roadside chipping. Given the relatively low capacity required (under 65 green tonnes (71 tons) per shift), possible choices of equipment for harvesting include only feller bunchers, short-wood forwarders, and grapple and choker wheeled skidders. This equipment can be used in a variety of combinations, but only manual felling with either a choker wheeled skidder or a grapple skidder were deemed to be low enough in cost and adequately proven in operations. The grapple skidder would be appropriate only at higher production rates.



Bonavista Fuelwood Supply Study

Economic Analysis:

Assuming a system producing 50 tonnes (55 tons) per 8-hour shift and using the manual fell/Timberjack choker skidder/14" Trelan chipper system (or equivalent), direct production costs for chips at roadside would amount to $12.70 per green tonne ($11.52 per ton). Adding indirect costs for road building, maintenance, snow clearing and overhead brings total production costs to just over $20 per tonne ($18 per ton). Transportation costs in a tandem pallet truck would average $9.14 per tonne ($8.29 per ton) based on 10 tonnes (11 tons) per load. In addition, central storage facilities for 1,000 tonnes (1,100 tons) of whole trees would be needed to allow for two months of downtime in the spring. Mill residues are estimated to cost $10 per green tonne ($9.00 per ton) in van; total costs after scaling/ weighing and trucking would be $20.14 per tonne ($22.20 per ton). Adding forest biomass and sawmill residues to small-scale chipping by independent contractors yields 15,000 green tonnes (16,535 tons) and total costs of $410,895, or $27.40 per green tonne ($24.85 per ton). This calculation is based on 45% moisture content (established by experiment). On an oven-dried basis, tonnage would drop to 8,250 tonnes (9,094 tons) and costs would rise to $49.81 per oven-dried tonne ($45.19 per ton).

The portion of the wood-chip production harvested from the forest represents about 2% of the available volume of wood identified in the study. With regrowth, this rate of production (or a higher rate) could be maintained indefinitely into the future.

Availability:

The kinds of information developed in this study can be prepared by any consultant familiar with forest industry practices and the forest resource base in a local area.

Further Information:

For further information and a copy of the final technical report contact:

- ENEROPTIONS
  Energy Branch
  Department of Mines and Energy
  Government of Newfoundland and Labrador
  P.O. Box 4750
  St. John's, Newfoundland
  A1C 5T7
  (709) 576-2411

- Warren Strong
  (re: ENEROPTIONS)
  Highlands Contracting Ltd.
  P.O. Box 446
  Gander, Newfoundland
  A1V 1W8
  (709) 651-3748

ENERGY OPTIONS CASE STUDY

NFLD 31

Wood-Chip Heating

NEWFOUNDLAND HARDWOODS LTD. — CLARENVILLE, NEWFOUNDLAND

Technology:
A medium-scale wood burning heating system

Demonstration Project Manager:
Maurice Mills
Acres International Ltd.
44 Torbay Road
St. John's, Newfoundland
A1A 2G4

Location:
Clarenville, Newfoundland

Annual Savings: $118,800
32% of previous fuel costs

Payback Period: 4.9 years

Applicable to:
- Manufacturing plants
- Institutions

Description:
Newfoundland Hardwoods Ltd. displaces approximately 1.36 million L (300,000 gals) of Bunker C oil annually and replaces it with 7,200 tonnes (7,900 tons) of green wood chips for a saving of $118,800 annually. The company installed a new 300 hp Northfab wood-burning system to replace its oil-burning system to produce steam for its asphalt and creosote plant. Wood chips from mill waste and whole tree chips are supplied locally, which has created local employment. A local engineering consultant provided project management and assisted with integration of the purchased system into the existing plant.

Wood-fired boiler in position and ready for building enclosure.

Benefits:
- 1.36 million L (300,000 gals) of Bunker C oil were displaced by 7,200 green tonnes (7,900 tons) of chips for a saving of $118,800 annually;
- Seven permanent jobs in the wood fuel supply business were created;
- Sulphur emissions have been reduced substantially as wood chips contain almost no sulphur;
- Reduced fire hazard and easier reforestation on land harvested for wood chips.

ENEROPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENEROPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Performance:

The demonstration proved the technical and economic feasibility of a medium-scale wood burning heating system. No problems were experienced in installation, start-up or operations.

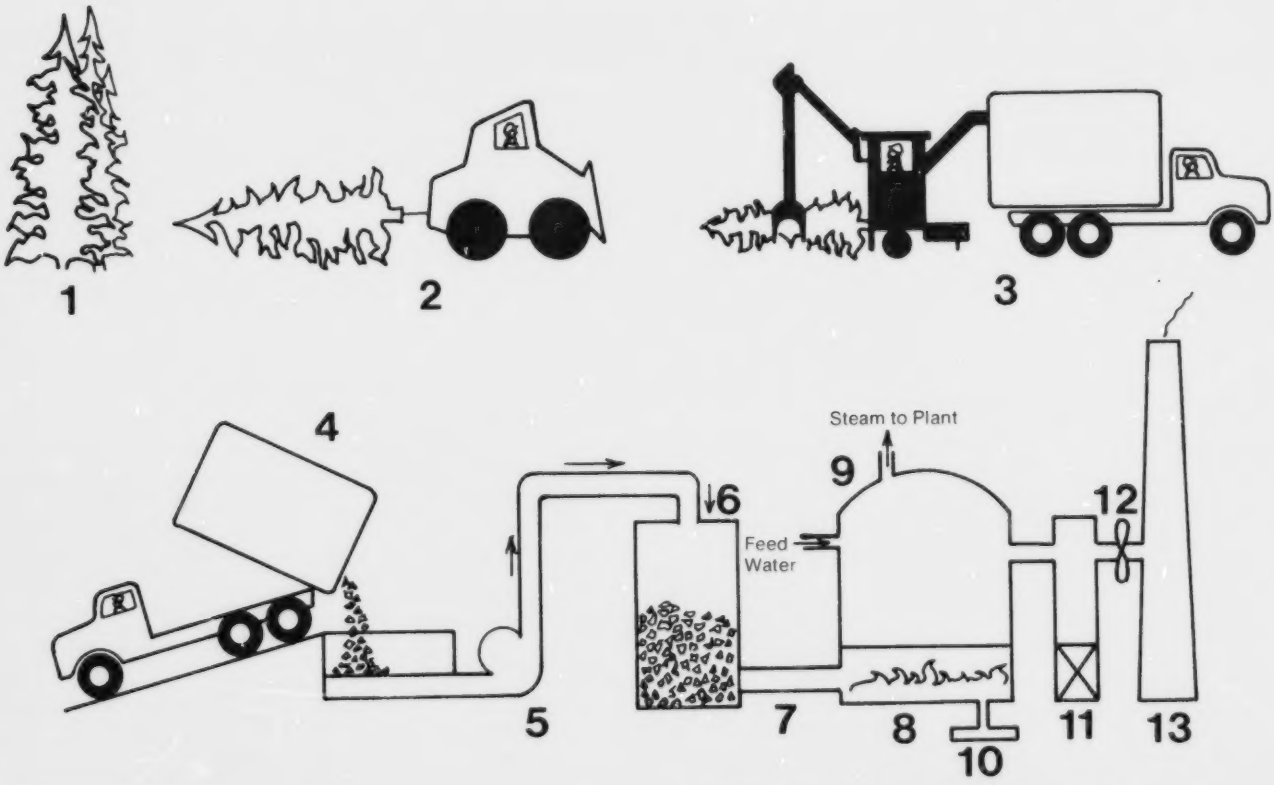
- The system has performed above expectations with the Northfab boiler providing all of the required steam.
- The wood-fired system takes one-sixth the time to reach top capacity from a cold start as did the oil-fired boiler.
- A reliable source of wood chips will supply fuel at $33.50/green tonne ($30.39/ton) for a period of three years.

Technical Details:

The asphalt and creosote plant requires approximately 4,536 kg (10,000 lbs) of steam per hour at 1,034 kPa (150 psi) for the heating of asphalt tanks and the pressure treatment of timber. To meet these requirements, a 300 hp Northfab wood-fired boiler system was installed. The boiler system consists of a 4.9 m × 3.7 m (16 ft × 12 ft) boiler, a grit collector (with a 20 hp fan, grit bin, platform and accessories), an 11 m (35 ft) chimney and a stoker (screw type with a 2 hp motor, a 2 hp F.D. fan, and a 2 hp fuel metering screw).

The related material handling system has the following features:

- Silo 6 m × 6 m × 7.6 m (20 ft × 20 ft × 25 ft)
- Metal dumping bin
- Support frame and grating
- Live bottom for bin, 3 push-rods
- Unloading auger 46 cm (18 in)
- 6 m (20 ft) paddle conveyor to screen
- chip screen
- Incline conveyor to silo
- Electric starters for equipment and enclosure and control



1) Uncommercial Timber
2) Felled by chainsaw and skidded to roadside
3) Roadside Chipping
4) Chips delivered to Newfoundland Hardwoods
5) Chips screened and blown into silo
6) Four-day storage
7) Fuel feed to burner
8) Wood boiler (10,000 lbs. steam per hour, 150 psi)
9) Water infeed, steam out to plant
10) Ash Removal
11) Grit Arrester
12) Induced drift fan
13) Stack.

Material flow diagram for Newfoundland Hardwoods, Clarenville

Economic Analysis:

Capital Cost: $587,500

Payback Period: 4.9 years.

Operating Cost:

Bunker C oil 1,363,800 L @ $0.264/L	$360,000
Replaced with wood chips 7,200 tonnes @ $33.50/green tonne	($241,200)
Net Fuel Savings:	$118,800

Availability:

The boiler system was provided by:

- Northfab Systems
  P.O. Box 202
  Stratford, Ontario
  N5A 6T1
  (519) 271-5530

The engineering consultants were:

- Acres Consulting Services Limited
  St. John's, Newfoundland

Similar technology is available from other sources across Canada.

Further Information:

For further information and a copy of the final report, contact:

- ENEROPTIONS
  Energy Branch
  Department of Mines and Energy
  Government of Newfoundland and Labrador
  P.O. Box 4750
  St. John's, Newfoundland
  A1C 5T7
  (709) 576-2411

- Maurice Mills
  (re: ENEROPTIONS)
  Acres International Ltd.
  44 Torbay Road
  St. John's, Newfoundland
  A1A 2G4
  (709) 754-1710

Lac La Martre School Waste Heat Recovery

Technology:
Waste heat recovery from diesel generator

Demonstration Project Manager:
Mr. Dana Ferguson
Ferguson, Simek, Clark Ltd.
Box 1777
Yellowknife, N.W.T.
X1A 2P4

Location: Lac La Martre, N.W.T.

Annual Savings: $26,485
99% of oil consumption without heat recovery

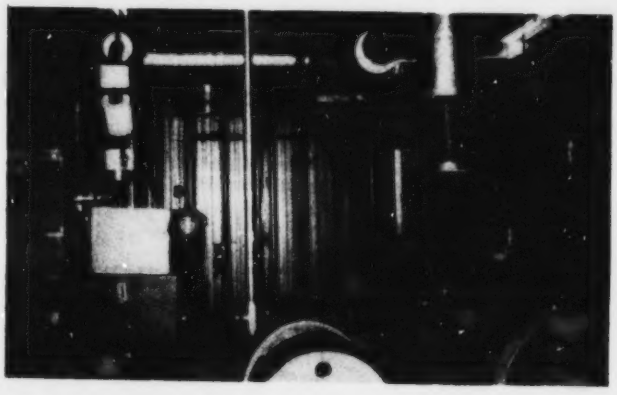
Payback Period: 9 years

Applicable to:
Remote communities served by diesel power plants and having suitable space heating/domestic hot water loads.

Description:

A school in a remote N.W.T. community is heated by waste heat from a diesel generator. In the summer of 1981, a new community school of 1,800 square metres (19,380 sq. ft.) was built at Lac La Martre, 164 km. northwest of Yellowknife. The new school incorporated many new energy conservation features and was situated 100 metres from an existing Northern Canada Power Commission (NCPC) diesel power plant.

A system to recover waste heat from the jacket water and exhaust was designed and installed on the existing NCPC diesel power plant. The waste heat is now transferred to the adjacent school where it provides space and domestic water heating. This process effectively reduces the school's boiler operation to a minimum, without affecting the NCPC plant production.



Benefits:

A number of benefits are realized through recovering waste heat from the generator's jacket water and exhaust. These benefits include:

- The waste heat recovery system provides almost 100% of the school's space and water heating requirements.
- The exhaust recovery unit cuts noise transfer from the generator so that it is now almost inaudible when standing outside the NCPC enclosure.

Performance:

The design and installation of the heat recovery system proceeded as expected, without encountering major problems. The system's performance has slightly exceeded expectations and no maintenance problems have been encountered.

After one complete heating season (1982-83), the project is considered to be very successful by all parties involved — the community, NCPC, maintenance staff, and the Government of the Northwest Territories (GNWT).

ENERGOPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENERGOPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

It was found that the NCPC load and the school's heat requirements are in phase. The actual quantity of heat supply and demand are well matched, particularly in the crucial winter months. It was determined that for each 1 kW of generator electrical output, 1.32 kW of recoverable waste heat is produced.

NCPC reported no operational or maintenance problems with the heat recovery system. NCPC indicated that the generators' engine temperature was being maintained at a satisfactory 80° C (176° F) with flue gas temperature fairly steady at 210° C (410° F).

The community and GNWT are similarly pleased with the resulting savings in the school's fuel oil requirements. Actual consumption for the first year of operation was 370 litres.

This represents an annual fuel oil savings of about 49,800 litres from the projected consumption — a 99% savings.

Problems encountered in the second year of operation have been attributed to a lack of trained and motivated staff to do routine maintenance on the distribution system.

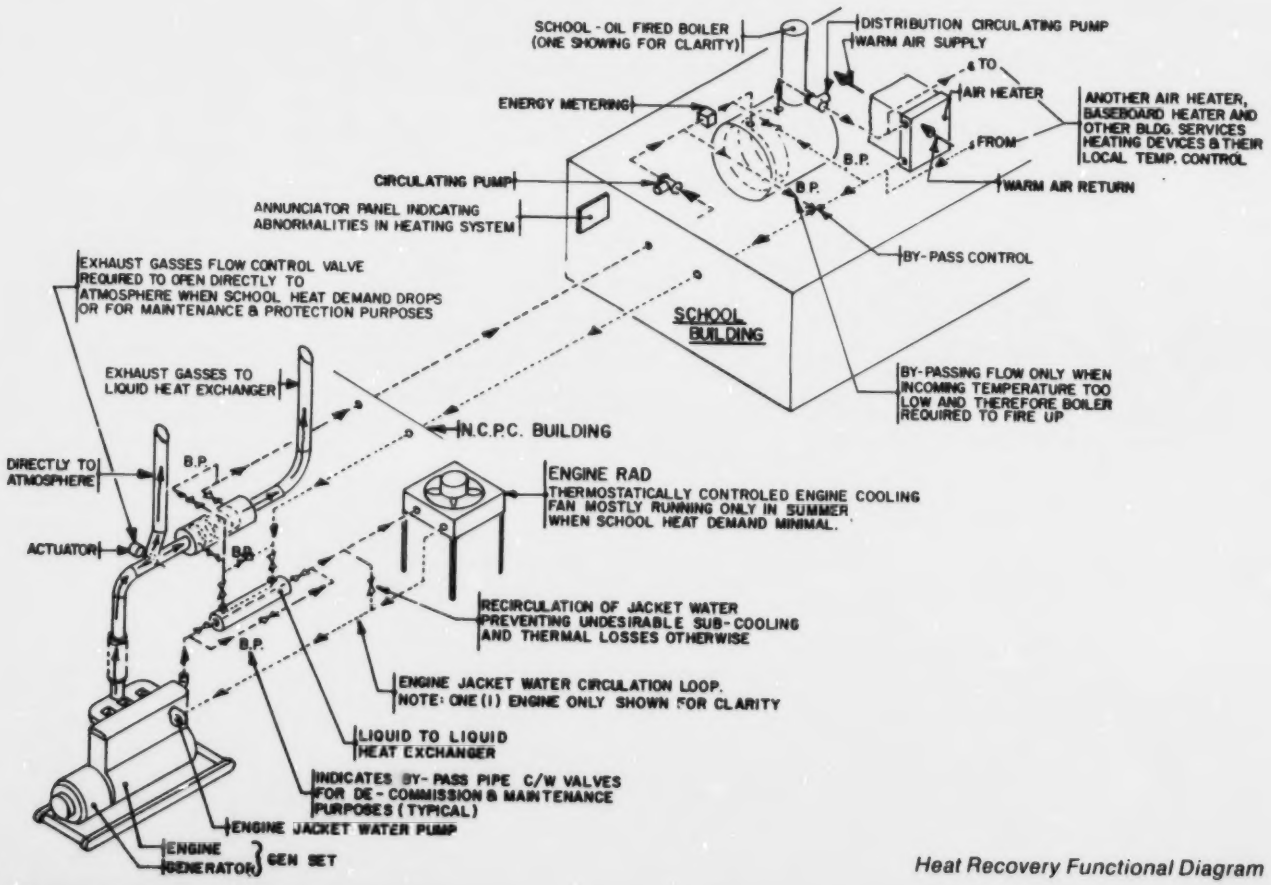
Technical Details:

Three NCPC generators provide the total community power supply. Two of these units — a Caterpillar 3406 with a 281.25 kVa generator and a Caterpillar D-342 with a "Kato" 187.5 kVa generator — are connected to the heat recovery system. Below is a functional diagram of the installed system.

Due to the size of the projected heating load and the plant's output capacity, waste heat is recovered from both the generators' jacket water and exhaust flue gas via installed heat exchangers shown in the functional diagram. When the generator output exceeds the school's load requirement, jacket water heat is rejected via the remote engine radiator which is equipped with a thermostatically controlled cooling fan. A control valve directs the flue gas to the atmosphere via a conventional muffler when exhaust heat recovery is not required.

The heating system is filled with a pre-mixed solution of 50% propylene glycol and 50% water. The diesel waste heat is transferred to the school using 63 mm schedule 40 welded steel pipes. The pipes are insulated with 38 mm thick polyethylene insulation wrapped in a 45 mil polythylene black jacket.

The insulated pipe was installed at a depth of .6 m. Soils are not thaw-stable in permafrost, consequently, timber sleepers were used extending beyond the influence of the thaw bulb created by the pipes.


SCHOOL - OIL FIRED BOILER (ONE SHOWING FOR CLARITY)
DISTRIBUTION CIRCULATING PUMP
WARM AIR SUPPLY
TO
AIR HEATER
ANOTHER AIR HEATER, BASEBOARD HEATER AND OTHER BLDG. SERVICES HEATING DEVICES & THEIR LOCAL TEMP. CONTROL
FROM
ENERGY METERING
B.P.
CIRCULATING PUMP
B.P.
WARM AIR RETURN
ANNUNCIATOR PANEL INDICATING ABNORMALITIES IN HEATING SYSTEM
BY-PASS CONTROL
EXHAUST GASSES FLOW CONTROL VALVE REQUIRED TO OPEN DIRECTLY TO ATMOSPHERE WHEN SCHOOL HEAT DEMAND DROPS OR FOR MAINTENANCE & PROTECTION PURPOSES
SCHOOL BUILDING
EXHAUST GASSES TO LIQUID HEAT EXCHANGER
BY-PASSING FLOW ONLY WHEN INCOMING TEMPERATURE TOO LOW AND THEREFORE BOILER REQUIRED TO FIRE UP
N.C.P.C. BUILDING
DIRECTLY TO ATMOSPHERE
B.P.
ENGINE RAD
THERMOSTATICALLY CONTROLED ENGINE COOLING FAN MOSTLY RUNNING ONLY IN SUMMER WHEN SCHOOL HEAT DEMAND MINIMAL.
ACTUATOR
B.P.
RECIRCULATION OF JACKET WATER PREVENTING UNDESIRABLE SUB-COOLING AND THERMAL LOSSES OTHERWISE
B.P.
ENGINE JACKET WATER CIRCULATION LOOP. NOTE: ONE (1) ENGINE ONLY SHOWN FOR CLARITY
LIQUID TO LIQUID HEAT EXCHANGER
INDICATES BY-PASS PIPE C/W VALVES FOR DE-COMMISSION & MAINTENANCE PURPOSES (TYPICAL)
ENGINE JACKET WATER PUMP
ENGINE GENERATOR
GEN SET

Heat Recovery Functional Diagram

The school heating system was designed to be completely self contained. It consists of: two oil-fired boilers, each with a rated output of 159 kW; perimeter baseboard heating; and two ventilation systems supplying tempered outside air as required. The domestic hot water is also supplied by the diesel waste heat, with cold water being circulated through tankless heat exchangers and stored in insulated tanks. An electric heater was installed as emergency backup only.

The school heating system was designed to operate at 62° C (144° F) which would normally be supplied from the NCPC recovery lines. The hot water passes in series from the NCPC recovery lines through the boilers, which will bring the water up to 62° C (144° F), if necessary. An operating aquastat controls the boilers when NCPC cannot supply enough heat.

If the NCPC water supply temperature falls below 49° C (120° F), the heat recovery line aquastat modulates a 3-way valve to recirculate the water back to NCPC rather than through the school heating system. A thermostat installed on the heating water supply line will initiate an alarm if the temperature drops below 43° C (109° F).

Separate circulating pumps for the school heating system and for transferring the hot water between the school and NCPC building are both located in the school boiler room.

Economic Analysis:

1. Capital and Installation Costs: $239,000

2. Cost of Heating School:

	Without Heat Recovery (estimated)		With Heat Recovery (actual)	
• Fuel oil (@ $0.58/L)	50, 150 L =	$29,087	370 L =	$ 215
• Boiler electrical and oil transfer pumps (@ $0.573/kWh)	745 kWh =	427	6 kWh =	3
• Recirculating pump (@ $0.573/kWh)	none		4,906 kWh =	2,811
		$29,514		$3,029

Net Savings = $26,485

3. Simple Payback Period: 9 years

Availability:

Ferguson, Simek, Clark Ltd. of Yellowknife, N.W.T. designed and supervised installation of the heating system.

NCPC personnel carried out all modifications to the power plant equipment. Similar consulting services and equipment are generally available across Canada.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Energy Conservation Division
  Department of Public Works and Highways
  YK Centre, 5th Floor
  Government of the Northwest Territories
  Yellowknife, N.W.T.
  X1A 2L9
  (403) 873-7203

Information on this demonstration project is also available from the consultant:

- Ferguson, Simek, Clark Ltd.
  (re: ENEROPTIONS)
  Box 1777
  Yellowknife, N.W.T.
  X1A 2P4
  (403) 920-2882

Super Energy Efficient Arctic Row Housing

BOREALIS CO-OPERATIVE — YELLOWKNIFE, N.W.T.

Technology:
New building energy efficiency

Demonstration Project Manager:
President
Borealis Co-operative Ltd.
Box 2039
Yellowknife, N.W.T.
X1A 2P5

Location:
Yellowknife, N.W.T.

Annual Savings: $133,250
75% compared with conventional construction standards

Payback Period: 3.7 years

Applicable To: Residential sector

Description:
The first multifamily dwellings in Canada to meet R-2000 energy efficiency standards are in Yellowknife, N.W.T. The Borealis Housing Co-operative Ltd. consists of 50 new town houses grouped into 9 blocks, ranging from duplexes to eight-plexes. The construction style is row housing on a common crawl space.

The units were constructed in 1983 using the latest recommended R-2000 energy conservation features and commercial products. These included southern orientation, increased insulation levels, sealed air-vapour barriers, poly electrical boxes, air-to-air heat exchangers, downsized propane furnaces in an enclosed furnace room, triple-glazed windows and an insulated crawl space on bedrock.

It takes a lot of insulation to achieve energy efficiency. These houses in the Borealis project need all they can get to protect them from frigid northern winters.

Benefits:
- Calculated annual fuel *savings* are approximately 75% of the consumption of units constructed to conventional energy efficiency standards.
- The project generated useful design alternatives for the treatment of the crawl space floor when situated on exposed bedrock.
- Incorporation of the energy efficiency features resulted in local tradesmen learning new skills and upgrading their employability.
- The project has clearly demonstrated that typical northern row housing can be adapted to incorporate state-of-the-art energy conservation techniques and can produce dramatic but cost-effective savings. The Hillside Co-operative in Frobisher Bay has adopted the same approaches.

ENEROPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program ENEROPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon

Performance:

Construction of the project was completed on time and within budget. Occupancy took place in October, 1983. The total budget for 50 units was $5.2 million or $104,000 average per unit.

Although complete monitoring data is not yet available, actual fuel consumption data — for a 3 month winter period — compiled for one block of three units, indicate an annual savings of about $8,000 or 75% of the estimated heating costs for the same block if constructed to conventional standards. The simple payback is 3.7 years.

The units have experienced three significant problems to date.

- there is an unequal distribution of heat between upper and lower floors. The lower floors are cool while upper floors are comfortable. In part, poor air circulation—combined with infiltration from the crawl space—is felt to be the cause.
- the air-to-air heat exchangers have developed ice build-up during severe weather. Retrofit of vanEE "Frost Busters" should provide a solution to this northern problem.
- frost build-up is occurring in the attics.

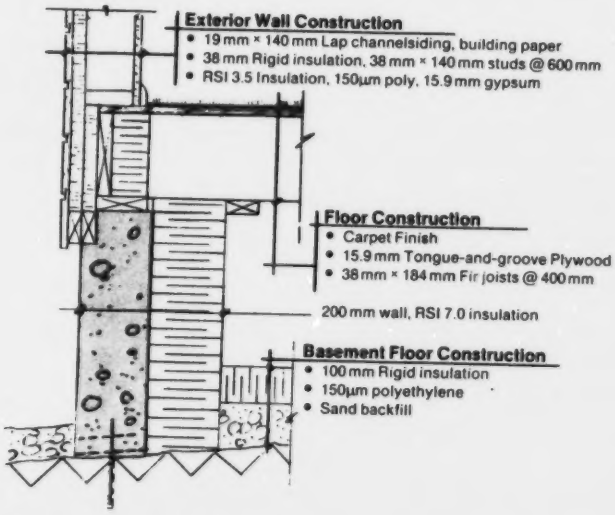
The installation of a return air duct on the lower floor is expected to resolve the first problem. Two speed circulating fans are also recommended for future applications. The Saskatchewan Research Council is currently investigating both of the remaining problems and a report suggesting remedial measures will soon be available.

Technical Details:

Each unit consists of: a living room on the lowest level; a kitchen, dining room, ½ bath, laundry and storage rooms on the main level, and; bedrooms and a bathroom on the upper level(s). Floor area is: 112 m² (1,200 ft²) in the two-bedroom units; 128 m² (1,380 ft²) in the three-bedroom units and; 153 m² (1,650 ft²) in the four-bedroom units.

The design and construction of the units particularly emphasized six energy efficiency features:

- Orientation - The Borealis Co-op site slopes to the south and consists of exposed bedrock. To maximize solar gain and minimize exterior area, the units are grouped into 9 blocks running on an east to west axis.
- Controlled Air Leakage - The sealing of the air-vapour barrier was carefully addressed and inspected. Particular attention was devoted to such areas as; the junction of the foundation and the framing; electrical fixtures; plumbing vents; and chimneys. Infiltration tests were conducted by NORSASK of Saskatoon; 92% of the units met or exceeded the allowable air leakage standard of 1.5 air changes per hour at 50 pascals.
- Levels of Insulation — The units were insulated to RSI 10.5 (R 60) in the roof, RSI 6.0 (R 34) in the walls and RSI 7.0 (R 40) in the basement.
- Heat Exchangers - To maintain air quality, a vanEE heat exchanger was installed in each unit to recover heat from the stale exhausted air. Fresh air is ducted to the return air plenum where it can be heated prior to distribution. To control humidity levels, the heat exchanger is connected to a humidistat which activates the unit at a predetermined humidity level.
- Windows - Triple-glazed windows were used.


Exterior Wall Construction
• 19 mm × 140 mm Lap channelsiding, building paper
• 38 mm Rigid insulation, 38 mm × 140 mm studs @ 600 mm
• RSI 3.5 Insulation, 150µm poly, 15.9 mm gypsum
Floor Construction
• Carpet Finish
• 15.9 mm Tongue-and-groove Plywood
• 38 mm × 184 mm Fir joists @ 400 mm
200 mm wall, RSI 7.0 insulation
Basement Floor Construction
• 100 mm Rigid insulation
• 150µm polyethylene
• Sand backfill

Basement/Exterior Wall Section

- Heating System — Forced air, 90,000 Btu propane furnaces were downsized to provide a 40,000 Btu output. The furnaces are also equipped with electronic ignition, motorized flue dampers and night setback thermostats. Propane is also used for heating domestic hot water and for the operation of dryers and stoves.

Economic Analysis:

1. Capital and Installation Costs for Energy Efficiency Features
(incremental costs)

Total for 50 units:	$502,343
Average cost/unit:	$ 10,047

The energy efficiency features appear to represent just under 10% of the total building cost.

2. Annual Savings

Estimated fuel cost/unit (without energy upgrading)	$ 3,560
Actual fuel cost/unit (with energy upgrading)	$ -895
Net Annual Saving	$ 2,665

3. Simple Payback Period: 3.7 years

Availability:

The Borealis Co-op was designed by Larrie Taylor, Architect Ltd. of Edmonton, Alberta and constructed by PCL Ltd., a local Yellowknife contractor.

All products and services employed in this project are available in major centres throughout Canada.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Energy Conservation Division
  Department of Public Works and Highways
  YK Centre, 5th Floor
  Government of the Northwest Territories
  Yellowknife, N.W.T.
  X1A 2L9
  (403) 873-7203

Further information on this demonstration project is also available from:

- Borealis Co-operative Ltd.
  (re: ENEROPTIONS)
  Box 2039
  Yellowknife, N.W.T.
  XIA 2P5
  (403) 920-2467
- Larrie Taylor
  (re: ENEROPTIONS)
  Larrie Taylor, Architect Ltd.
  200-9959 Whyte Avenue
  Edmonton, Alberta
  T6E 1Z1
  (403) 432-1028

Snowshoe Inn Ltd. Waste Heat Recovery

Technology:
Waste heat recovery and distribution from diesel jacket water and exhaust

Demonstration Project Manager:
Mr. Dana Ferguson
Ferguson, Simek, Clark Ltd.
Box 1777
Yellowknife, N.W.T.
X1A 2P4

Location:
Fort Providence, N.W.T.

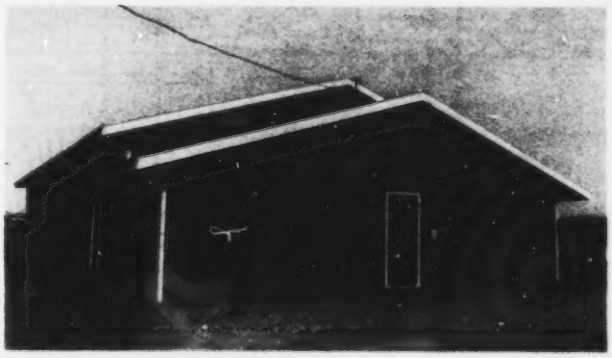
Annual Savings: $128,000
68% of conventional electricity and heating costs

Payback Period: Under 2 years

Applicable to:
Remote communities served by diesel power plants and having suitable space heating/domestic hot water loads.

Description:
The Snowshoe Inn Ltd. is located in Fort Providence, N.W.T., a remote community situated 233 air kilometres (145 miles) southwest of Yellowknife, N.W.T.

In 1971, the owner began to plan for a major expansion of the Snowshoe Inn's facilities. In order to keep power and heating costs to a minimum, he installed his own diesel power system with heat recovery. Waste heat from both the diesel water jacket and exhaust is recovered and provides space heat and domestic hot water to the adjoining buildings.



Snowshoe Inn craft shop/restaurant complex

Benefits:
This project is providing very substantial economic benefits to the Snowshoe Inn. Based on an economic and engineering review of the system, it is estimated that the Snowshoe Inn is realizing an annual savings of approximately 65% on its total power, space heat and domestic hot water costs.

The project has also shown that the use of an underground steel culvert to distribute piping is a very practical idea for the North. Hot and cold water pipes, sewage pipes and even electrical cables can be run through the culvert. Because the culvert is 1 m (3.3 ft) in diameter, the piping is easily accessible and if warm air is blown through, no insulation is required on thaw-stable soils.

Finally, the project has demonstrated that underfloor heating is a practical approach to using low-grade waste heat for space heating purposes.

ENEROPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENEROPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Performance:

When installed in 1973, cost savings were estimated to be $2,500/month. Actual savings slightly exceeded this projection and their value has increased substantially over the past 12 years due to both the rapid increase in fuel costs and the continued expansion and modification of the system.

The project has benefitted significantly from the owner's strong background in mechanical engineering. Over the last 12 years he has carried out numerous system modifications and improvements.

Three improvements were particularly important:

- the installation of a heated 1,000 mm galvanized steel culvert which serves as a utilidor;
- the replacement of the conventional polyethelene distribution piping with polybutylene pipe in order to overcome leakage problems that occured as a result of radial cracks which developed at the joints;
- the installation of underfloor heating in buildings.

Technical Details:

Three diesel generators provide the power, space heat and domestic hot water requirements of the Snowshoe Inn. They are: a GM 4-71 diesel with a 75 kW Tamper generator; a GM 6-71 diesel with a 100 kW Tamper generator; and a turbo charged GM 6-71 diesel with a 175 kW Brown Boveri generator.

Waste heat is recovered from both jacket water and exhaust gases. Details of the jacket water and exhaust heat recovery system are shown in Figure 1.

The heating system is an "open" system operating at a pressure of approximately 75 kPa (11 psi). This pressure is created by the static head of the 18,000 litre (3,960 gal) storage/surge tank, shown in Figure 1. A 200 litre (44 gal) header tank, located on top of the 18,000 litre storage tank, is connected to the cold water supply and maintains the system capacity.

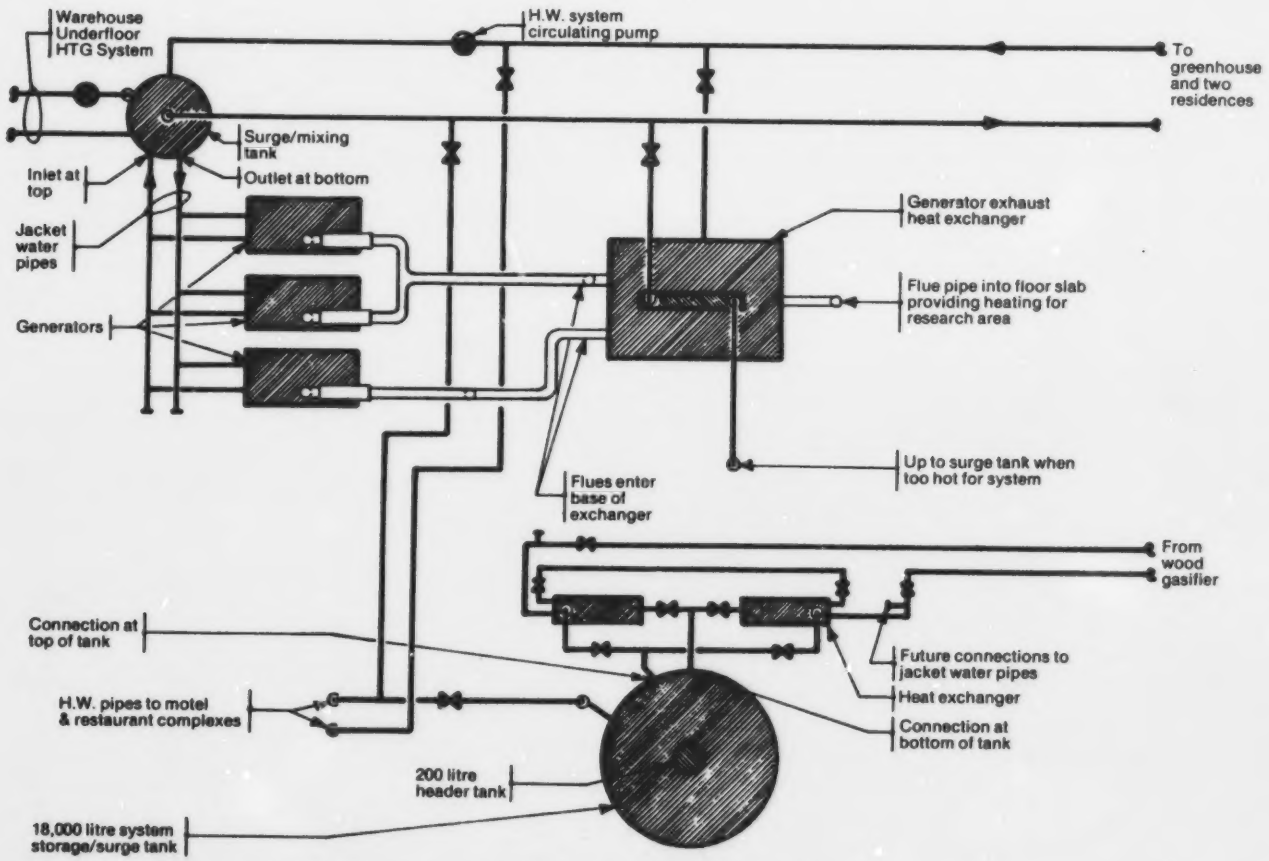

Warehouse Underfloor HTG System
H.W. system circulating pump
To greenhouse and two residences
Surge/mixing tank
Inlet at top
Outlet at bottom
Jacket water pipes
Generators
Generator exhaust heat exchanger
Flue pipe into floor slab providing heating for research area
Up to surge tank when too hot for system
Flues enter base of exchanger
From wood gasifier
Connection at top of tank
Future connections to jacket water pipes
Heat exchanger
H.W. pipes to motel & restaurant complexes
Connection at bottom of tank
200 litre header tank
18,000 litre system storage/surge tank

Fig. 1 Schematic of generators' jacket water and exhaust heat recovery systems

The distribution system is shown in Figure 2. In 1982, the previous wooden utilidor system was replaced by a 1 m (3.3 ft) diameter galvanized steel culvert. This steel culvert is used as an oversized utilidor and runs underground from the warehouse to the restaurant and new motel. As shown in Figure 2, a second section of underground culvert is planned as a replacement to the current above-ground extension to the distribution system.

The culvert contains the two hot water pipes carrying the diesel waste heat as well as a cold water pipe. Polybutylene pipe is now used instead of polyethelene pipe in order to avoid the problem of cracking. Excess warm air from the generator room is blown through the culvert. This maintains the air temperature inside the culvert well above freezing as well as keeping the pipes' heat loss to a minimum.

Hot water from the waste heat recovery system provides space heat to: a warehouse, a research building, a greenhouse, two residences and a motel and restaurant complex.

Although the heating system in each building has its own unique characteristics, most of the buildings are now provided with underfloor heating. For example, in the motel office and residence, 15 mm polybutylene pipes were laid on the wooden floor and clamped down. To keep the pipes flat, chicken wire was also laid across the floor and tacked down. A 32 mm thick layer of lightweight concrete was then laid on top of the pipes, and followed by the floor finish. Electric baseboard heaters have also been installed to provide temperature "fine tuning", if required.

Domestic hot water is also provided by the heat recovery system. Electric water heaters are used to increase the water temperature, if required.

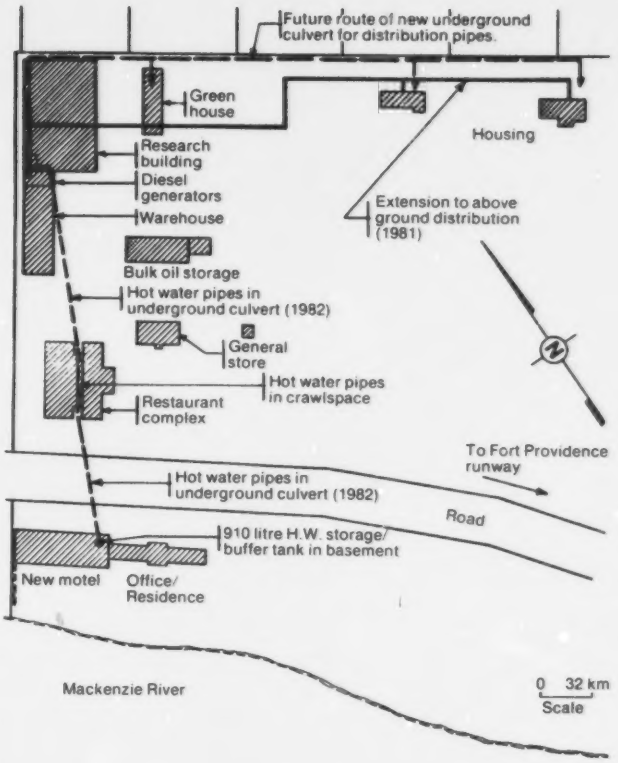


Fig. 2 Snowshoe Inn site upgraded hot water distribution system

Economic Analysis:

The capital cost of the original system installed in 1973 was $50,000. This included two diesel generators, the heat recovery and overground distribution system and labour (except for that of the owner). Annual savings attributed to heat recovery in 1973 were approximately $30,000. The simple payback on the original system was therefore less than 2 years.

In 1982, Ferguson, Simek, Clark Ltd. documented the system and undertook an updated economic analysis.

Actual electricity consumption records from the Snowshoe Inn's diesel power plant were totalled for the 12 month period May 1981 to April 1982. These figures were then used to determine what the Inn's electricity costs would have been if power had been purchased from the local utility — Alberta Power Ltd. Similarly, records of actual space heating requirements were used to estimate the Inn's hypothetical heating costs if, instead of using waste heat, fuel oil had been purchased and burned in a conventional heating system.

These hypothetical costs were then compared to the Inn's actual total power and space heating costs incurred with the diesel generator/heat recovery system. The results are presented below:

Estimated conventional electricity cost:	$168,000
Estimated conventional space heating cost: 74,074 L @ $0.27	20,000
Estimated Total Conventional Cost:	$188,000
Actual diesel fuel cost: 218,000 L @ $0.27	$ 58,860
Actual engine lubricant oil cost: 818 L @ $1.00	818
Actual Total Cost:	($ 59,678)
Annual Energy Savings: (Estimate)	$128,322

Availability:

The owner designed and supervised the installation of the entire system himself.

The technology is widely available through engineering consultants, contractors and suppliers in major centres throughout Canada.

Further Information:

Further information and a copy of the 1982 report is available from:

- ENEROPTIONS
  Energy Conservation Division
  Department of Public Works and Highways
  Government of the Northwest Territories
  YK Centre, 5th Floor
  Yellowknife, N.W.T.
  X1A 2L9
  (403) 837-7203

The 1982 report was prepared by:

- Mr. Dana Ferguson
  (re: ENEROPTIONS)
  Ferguson, Simek, Clark Ltd.
  Box 1777
  Yellowknife, N.W.T.
  XIA 2P4
  (403) 920-2882

Wood Heating of Fort Smith Water Supply

Technology:
Large-scale, direct combustion of wood chips

Demonstration Project Manager:
Jack Dueck
Apsco Engineering Ltd.
P.O. Box 270
Cremona, Alberta
T0M 0R0

Location:
Fort Smith, N.W.T.

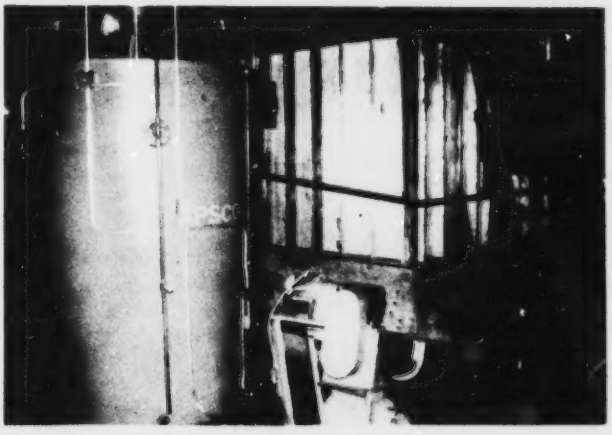
Annual Savings: $44,471
100% of fuel oil previously used

Payback Period: 4.6 years

Applicable to:
- a wide range of institutional, municipal and commercial space and water heating applications
- of particular interest to northern communities requiring heated water supply.

Description:
Fort Smith, N.W.T. is saving over $44.000/year and creating local employment by heating its water supply with wood. Fort Smith, located approximately 300 km (185 miles) south of Yellowknife, must heat its water supply during much of the year. As in many communities in the Northwest Territories, the town's water supply was previously heated by conventional oil-fired boilers. However, escalating fuel oil prices dramatically increased the system's operating costs and prompted the search for a less expensive alternative.

The town's water supply is now heated by means of a 4.0 MBtu/hr Apsco Model WW1000 wood-fired hot water boiler unit. The boiler is fuelled by wood chips, processed on-site from locally purchased cordwood.



The wood-fired boiler is seen to the left and the wood-chip storage bunker is to the right. The inclined auger is seen in the foreground.

Benefits:
- In its first year of operation, the project resulted in the displacement of approximately 160,000 litres (35,195 gallons) of No. 2 fuel oil.
- Once start-up problems, related to chip bridging in the storage bin, are overcome, it is expected that the project will result in the total displacement of approximately 200,000 litres (45,000 gals) of No. 2 fuel oil by approximately 400 cords of local wood.
- The new wood boiler has a larger capacity than the oil boilers. This enables the water supply to be maintained at a higher and more optimal temperature (4.4° C) for more effective water treatment than previously (2° C).
- Three permanent part-time jobs have been created in connection with the harvesting, delivery and chipping of local cordwood. Funds spent on fuel now stay in the community.

ENERGOPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENERGOPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Performance:

The design and installation of the system proceeded as expected and no problems were encountered. The boiler has performed at, or above, expectations since installation. A minor start-up problem was encountered with the wood chipper but was quickly identified and eventually remedied. There has been a continuing problem, however, with the wood-chip handling system. Each problem is outlined below.

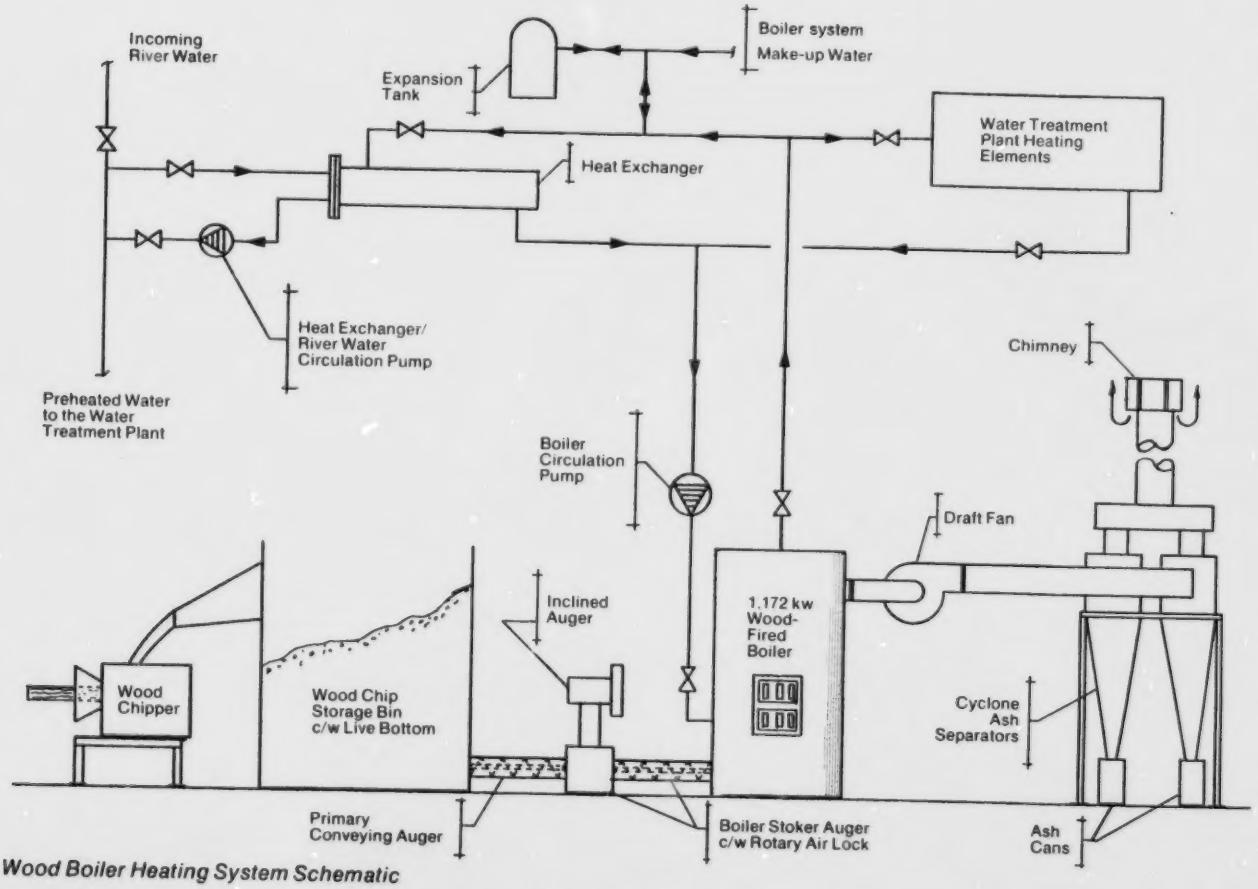
- Wood chipper — The attachment blades originally provided by the supplier were shorter than those specified by the design engineer. As a result, the chips were not being adequately thrown from the chipper unit to the conveyor belt. The problem was quickly identified and proper replacement blades were provided by the supplier. However, due to the inexperience of the on-site personnel, the replacement blades were not installed for several months. Once the replacement blades were installed, the chipper unit performed well.
- Wood-chip handling system — A continuing chip bridging problem exists with the hydraulic live bottom in the storage bin. This problem has lowered the system's availability to about 80% and is currently under investigation but is felt to be correctable.

Technical Details:

The schematic diagram shows the new wood boiler system. All facilities, including the chipper and storage bunker, are located indoors in an insulated steel building.

Wood fuel is chipped to allow automatic feeding of the boiler. The wood-chip storage bin has a live bottom which allows the primary auger at the base of the storage bin to meter the flow as required. The primary auger has a variable speed drive enabling the boiler feed rate to be adjusted according to heating requirements and/or fuel moisture content. A rotary air lock provides a separation between fuel and the firebox.

The Apsco Model wood-fired boiler is a three-pass, vertical fire tube boiler with a design thermal efficiency of 75%. The design allows the hot gases from the firebox to travel vertically through the boiler in three passes before exiting. Primary combustion air is provided from beneath the boiler. The gases produced during primary combustion are burned above the wood chips when mixed with secondary air. Both the fuel feeding rate and the air supply are adjusted to achieve an efficient fuel/air mixture under various operating conditions.



Wood Boiler Heating System Schematic

The boiler is supplied with a complete set of controls to maintain a preset boiler supply water temperature. The water side of the boiler supplies two separate loops. The primary loop feeds the new heat exchanger which heats part of the incoming river water before it enters the water treatment plant. The portion of the river water (at .5° C) that passes through the heat exchanger has its temperature raised to a point that, when mixed with the remaining portion, results in a water temperature of approximately 4.4° C (40° F).

The second loop from the boiler heats the water treatment plant. The existing oil-fired boilers now serve as backup.

As a result of the extremely high boiler hearth temperatures, almost all of the hydrocarbons are consumed and only fly ash remains. The fly ash is separated from the exhaust emissions with high efficiency cyclones.

Economic Analysis:

Capital and Installation Costs: $206,874

Simple Payback Period: 4.6 years.

Avoided Cost of Fuel Oil (195,138 L @ $0.353):		$ 68,835
Annual Operating Cost for Wood Boiler		
• Cost of wood supply:		
- Harvesting and delivery (392 cords @ $37.50)	$14,700	
- Labour for wood chipping (336 hrs @ $8)	$ 2,688 (1)	
• Incremental maintenance cost:	$ 469 (1)	
• Incremental electricity cost:	$ 6,507 (2)	
Total	$24,364 (3)	($ 24,364)
Net Annual Savings		$ 44,471

Notes:

1. Incremental labour costs for wood chipping and regular maintenance are site-specific and are dependent on current labour loading. In many locations, these tasks may be handled by existing staff.
2. Incremental electricity costs are primarily for operation of the electric chipper; in Fort Smith the levy of an energy demand charge of $4,771 makes the operation of an electric chipper far more expensive than the comparable operating cost of a gas-powered chipper. Additional annual operating cost savings of approximately $4,000 are possible through the use of a gas-powered chipper.
3. In those locations where a gas-powered chipper is used and existing staff are able to perform wood chipping and regular maintenance duties, annual operating costs for a comparable wood system may be as low as $21,000. This would result in a simple payback of 4.3 years.

Availability:

The system was designed and installed by Apsco Engineering Ltd. of Cremona, Alberta.

The technology is available through contractors, suppliers and engineering consultants in major centres throughout Canada.

Further Information:

Further information and a copy of the final report are available from:

- ENERGOPTIONS
  Energy Conservation Division
  Department of Public Works and Highways
  Government of the Northwest Territories
  Yellowknife, N.W.T.
  X1A 2L9
  (403) 873-7202

Information on this demonstration project is also available from the consultant.

- Mr. Jack Dueck
  (re: ENERGOPTIONS)
  Apsco Engineering Ltd.
  P.O. Box 270
  Cremona, Alberta
  T0M 0R0
  (403) 286-2199

Computer-Controlled Traffic Signals

THREE ONTARIO MUNICIPALITIES

Technology:
Computerized Traffic Signal Control Management System

Demonstration Project Manager:
Transportation Technology and Energy Branch
Ontario Ministry of Transportation and Communications
1201 Wilson Avenue
Downsview, Ontario
M3M 1J8

Location:
City of Brantford and the Regional Municipalities of Waterloo and Durham

Annual Savings: $300,000 to $2,500,000
Estimated by computer simulation

Payback Period: under 1 year

Applicable To:
Small and medium-sized cities
- with outdated control equipment
- experiencing frequent maintenance problems
- with limited in-house engineering resources
- experiencing rapid growth or more frequent traffic congestion problems

Description:
Three Ontario municipalities improved their traffic operations and reduced the rate of fuel consumption for motorists in their respective communities with the installation of cost-effective computerized traffic control systems.

This demonstration project, involving the city of Brantford and the Regional Municipalities of Waterloo and Durham, indicated that computerized systems are economically feasible solutions for upgrading control facilities of small to medium-sized cities and urban areas.

In each case, a standard system design package was installed which utilized off-the-shelf hardware and software — with a minimum of modifications — to improve traffic flow.

The system controls and coordinates traffic flow with on-line programs via centrally located 16-bit minicomputers linked by communication lines to remote control equipment located at each controlled intersection. Communication options included leased telephone lines and municipally-owned cable systems.

Benefits:
The following figures and facts are based on generally accepted computer simulations for these and similar projects.

- Improvement in traffic operations signal systems — achieved through reduction of travel time delay — over uncoordinated traffic.
- Estimated fuel consumption per vehicle is reduced by approximately 10% under normal driving conditions.
- A reduction in stops by about 15% correspondingly results in significant decreases in fuel consumption and resulting exhaust emissions from vehicles.
- There are fewer rear-end collisions due to smoother traffic flows.
- Higher traffic speeds can be maintained safely.
- The incidence of traffic congestion and resulting delays is reduced.
- Road capacity is increased.
- More productive use of manpower stemming from efficiency of signal control and the systems' ability to collect, analyze and monitor traffic conditions.
- The systems can detect equipment malfunctions immediately.
- Collectively, these benefits translate into savings of millions of dollars over the life of the system.

ENERGOPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENERGOPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Performance:

The success of these demonstrations showed that three municipalities, with extensive assistance from the Ontario Ministry of Transportation and Communications (MTC), could effectively share costs and technologies.

Savings in equipment acquisition were achieved as a result of joint procurement. A cooperative information sharing approach was also adopted, during the implementation stage, by the engineering staffs of the three municipalities.

Several revisions were required to the software and hardware to overcome technical problems encountered during implementation of the systems. Once the systems were installed, they functioned satisfactorily.

The central system requires little maintenance. Innovative communication concepts were developed on the controller's side of the system which resulted in communication cost savings of up to 50%. Initially, a considerable amount of staff effort was expended to make the necessary modifications to the controllers.

A number of administrative problems occurred during the installation, including departure of the software subcontractors and a heavy turnover in the suppliers' staff which resulted in additional delays. These problems were eventually resolved.

Technical Details:

The City of Brantford and the Regional Municipalities of Waterloo and Durham proved the benefits of computer control in coping with increasing traffic congestion within their boundaries.

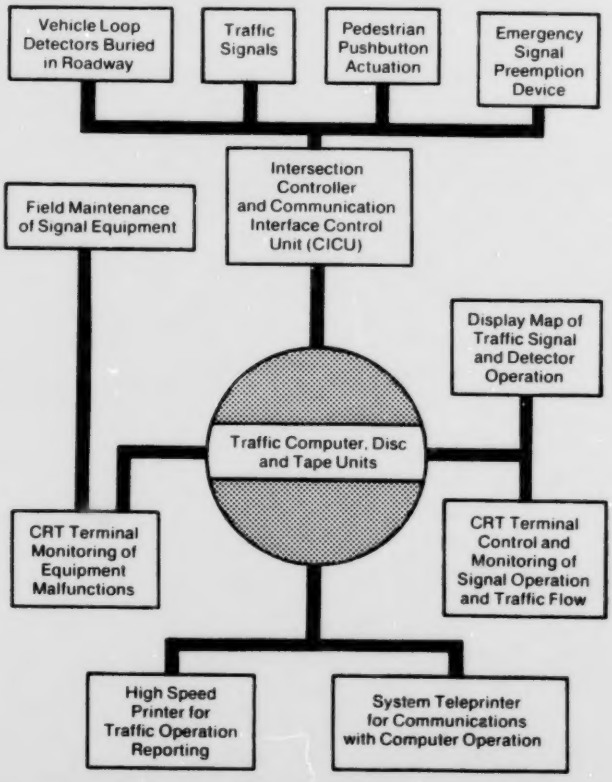
The solution to their problem was to upgrade their traffic operations, utilizing computerized technology under the Municipal Traffic Control Systems (MTCS) program, initiated under the auspices of the Ontario Ministry of Transportation and Communications (MTC). This program demonstrates that small to medium-sized urban areas can benefit from computer-based traffic control systems. Prior to the introduction of the MTCS, computerized traffic control was restricted to large metropolitan centres because of the considerable investment required for custom development of the hardware and software.

Under the arrangement with the MTC, a common functional specification was developed, which was then refined to meet the needs of the individual municipalities. A two-staged tendering process was initiated, comprising unpriced technical quotations from suppliers followed by refined priced proposals from a short list of suppliers. The contract for the three domonstrations was awarded to Canadian General Electric Co. Ltd., Toronto.

The MTCS computerized traffic control system consists entirely of off-the-shelf components, subject to only minor modifications specific to each municipality. The system is illustrated in the schematic diagram. Each system consists of a centrally located minicomputer with communication links (either leased telephone lines or municipally-owned cable) to the signal controller of each intersection. The central computer's traffic application software contains a predetermined set of area-wide timing plans which govern the signals of the system on a time-of-day basis.

The central computer manages the time interval and signal phase advances of each individual signal controller via the communication links. When a signal timing plan change is scheduled, the central computer adjusts the operation of all affected signal controllers from the prior signal timing parameters (i.e., split and offset) to the current set of timing parameters in a safe and smooth transition over several cycles lengths. Signal timing plans are developed off-line using the computer-based traffic Signal System Timing Optimization Program (SSTOP), now commonly used throughout the industry. With the use of system vehicle detectors embedded in the roadway at key locations, the volume pattern of traffic can be directly monitored by the central computer for the purpose of performance measurement and limited application of traffic-responsive signal control operation. In addition, local vehicle detectors embedded in the lanes of side streets and left-turn storage lanes provide for local intersection actuation in the overall system control and monitoring operation. Commands from pedestrian push buttons and emergency signal preemption devices can be monitored and served by the central computer's operation. The computer system also monitors and analyses traffic conditions and detects equipment malfunctions immediately, providing all such information to staff in the form of standard reports on a spontaneous or scheduled time-of-day basis.

The success of the MTCS Project has encouraged a number of other Ontario municipalities to follow suit. Mississauga, Brampton and London are in the process of acquiring the system and several others are seriously considering installing one.


Vehicle Loop Detectors Buried in Roadway
Traffic Signals
Pedestrian Pushbutton Actuation
Emergency Signal Preemption Device
Intersection Controller and Communication Interface Control Unit (CICU)
Field Maintenance of Signal Equipment
Display Map of Traffic Signal and Detector Operation
Traffic Computer, Disc and Tape Units
CRT Terminal Monitoring of Equipment Malfunctions
CRT Terminal Control and Monitoring of Signal Operation and Traffic Flow
High Speed Printer for Traffic Operation Reporting
System Teleprinter for Communications with Computer Operation

Economic Analysis:

The costs associated with installing a computer-based traffic control system are highly dependent upon the nature of the existing system and the communications alternatives available.

Actual monitoring of fuel savings was not undertaken. However, estimated savings are based on computer simulations undertaken as part of this project and other system installations.

The following section provides available details on the installed costs of the system, annual operating costs including maintenance and communications, the estimated annual fuel savings in terms of dollars to the motoring public and the resulting estimated payback periods:

Capital Costs

	Equipment (1) Cost	Installation (2) Cost	Total Installed Cost
Region of Waterloo	$600,000	$200,000	$800,000
Region of Durham	$600,000	$244,000	$844,000

(1) Includes both computer and field equipment
(2) Includes labour provided by municipal employees

Annual Savings and Payback

	Estimated Annual Fuel Savings	Annual (3) Operating Cost	Net Annual Savings	Estimated Payback Period
Region of Waterloo	$2,000,000	$150,000	$1,850,000	under 1 year
Region of Durham	$1,500,000	$ 90,000	$1,410,000	under 1 year

(3) includes operational staff equipment maintenance and communications costs

Availability:

The hardware and software for these projects were supplied and installed by Canadian General Electric Co. Ltd., although other suppliers do supply similar systems.

Most small and medium-sized municipalities will also likely require the services of a qualified consulting engineer in acquiring and deploying these systems.

Further Information:

A copy of the final technical report is available from:

- ENEROPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  Room 606, P.O. Box 2009
  55 St. Clair Ave. East
  Toronto, Ontario
  M4T 1M2
  (416) 973-1608 or
  1-800-387-0733 (toll free in Ontario)

A brochure describing the MTCS Procurement Process, including functional specification and terms of reference, together with further detailed information, is available from:

- Mr. E.R. Case and Mr. G. Heti
  (re: ENEROPTIONS)
  Traffic Management and Engineering Office
  Room 236, Central Building
  Ontario Ministry of Transportation and Communications
  1201 Wilson Ave.
  Downsview, Ontario
  M3M 1J8
  (416) 248-3781

Exterior Insulation Retrofit

JOHN ORR TOWER—QUEEN'S UNIVERSITY

Technology:
Exterior building retrofit

Demonstration Project Manager:
Dr. Jim Brown
Director of Physical Plant
Queen's University
Kingston, Ontario
K7L 3N6
(613) 547-6640

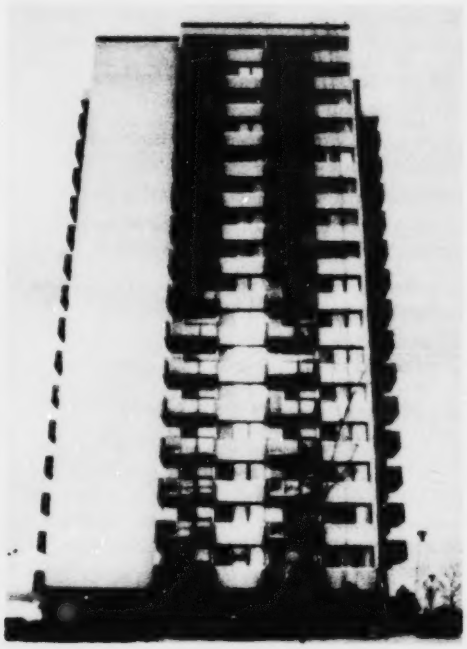
Location:
Kingston, Ontario

Annual Savings: $15,565
about 28% of pre-retrofit consumption

Payback Period: 9.8 years

Applicable to:
- Apartments
- Office towers
- Schools
- Universities

Description:
John Orr Tower, a 16-storey student residence at Queen's University, was a leaky building — heat leaked out through concrete walls and water leaked in through construction joints and windows — until an exterior retrofit in 1979/80 solved both problems. Using two different methods, 76 mm (3 in) of extruded polystyrene insulation was attached to the exterior of the poured-concrete building and then covered with steel siding. Airfoil guards were also added to the sill of each window to prevent rain from being driven in the track at the base of the sliding windows. By combining re-insulation with a necessary exterior renovation project, both problems were addressed at a reasonable cost.



John Orr Tower—after recladding.

ENERGY OPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENERGY OPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Benefits:

- The heating load is reduced by 28% for an average annual savings of $15,565.
- The water infiltration problems are resolved, thus eliminating damage and inconvenience.
- Building comfort is increased for the occupants.
- Valuable experience was gained concerning both materials and techniques for exterior cladding of high-rise buildings.
- Four person-years of employment were created.
- The appearance of the building was enhanced, from bare concrete to corrugated, painted steel siding.

Performance:

The exterior retrofit of John Orr Tower succeeded in completely eliminating water leaks and no maintenance problems have been experienced to date.

The energy savings, which had been projected as high as 50% , have fallen considerably short. The average saving over the four years since the retrofit has been about 28%. The difference is attributed to poor heating system controls which are inadequate to handle the reduced surface heat losses. Individual units lack thermostatic control and are thus frequently overheated. Occupants compensate for this by opening windows — thus eroding the potential energy savings.

Efforts are underway to correct these problems and savings are expected to increase when the building is taken off the central steam supply.

Three problems were encountered during the actual recladding:

- The height of the building (52 m (170 ft)) necessitated the use of platform swing stages (3 different lengths for 3 different faces of the building);
- Irregular surfaces on the poured concrete required a considerable amount of shimming of the strapping material;
- The lack of an experienced contractor (for high-rise cladding) required the university to go to a cost plus contract.

These problems resulted in an extended construction period.

Two different methods of attaching the insulation and cladding were tried. Both were tested and proved equally strong but the metal channel system proved less expensive than wooden strapping.

Technical Details:

The John Orr Tower is a 52 m (170 ft), 16-storey apartment building constructed in a Maltese cross configuration. It contains 125 one-bedroom units in a gross area of 7,740 m^2 (83,314 ft^2). It was built in 1972 with cast-in-place concrete.

As the building came into use, three major problems became apparent:

- Total energy consumption was unusually high—487 kWh/m^2 (45 kWh/ft^2) for a typical year;
- Water leaked through the walls at construction joints;
- Windows leaked in driving rains due to blow-through in the track drains at the base of the sliding windows.

To correct these three shortcomings, a decision was made to carry out a re-cladding project with three distinct elements;

- The total energy consumption was to be improved by adding 76 mm (3 in) of styrofoam SM insulation to the outside of the building to provide RSI 2.6 (R 15);
- The leaking at the construction joints was to be eliminated by the installation of currugated, painted, interlocking steel siding which would act as a rainscreen;
- The problem of leaking windows was to be solved by adding an airfoil at the base of each window to reverse the effect of the wind.

Two different methods were used in applying the insulation to the walls.

The *first* method involved running 38 × 88 mm (2 × 4 in) strapping of construction grade cedar vertically on the building using a Hilti gun to drive the nails into the concrete.

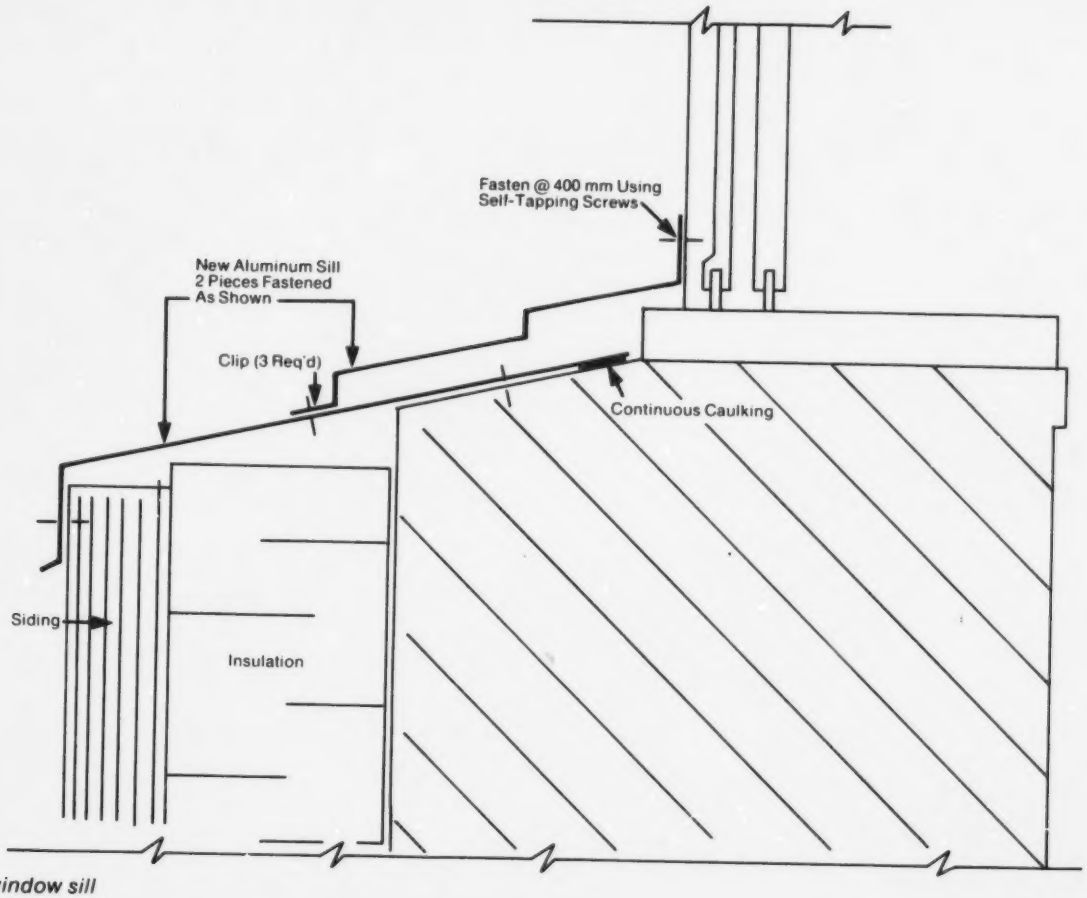
The first layer of 38 mm (1 ½ in) polystyrene was then wedged between these straps—a toe nail was put in places where it was fitting loosely. Having completed a side of the building with one layer, 38 × 38 mm (2 × 2 in) strapping of construction grade cedar was nailed horizontally to the vertical strapping and a second layer of polystyrene was then placed over the first.

The *second* method used was the "insulok" method which utilized a steel cuff which ran directly through channels made in the polystyrene insulation. In this process, only one layer of 76 mm (3 in) thickness polystyrene was used. To attach the steel cuff, a Hilti gun could have been used, however, the "Grip con" system, consisting of a patented drill bit and serrated nail which fitted the drilled hole, was found to be more accurate.

Both methods of applying the insulation were tested and produced the same endurance results; however, the metal channel system proved somewhat less expensive.

The window leaks caused by blow-through were corrected by the installation of an airfoil consisting of two pieces of shaped aluminum (see illustration). The first piece overhung the siding and continued up to the old window sill where a line of continuous caulking was added. A second piece was placed over the first, and fastened with self-tapping screws to a point well above the continuous caulking and to a point half way down the first piece. The new sill guards against water blow-through and channels water that does get through away from the window water tracks to an opening where it will drain down the side of the building.

The installation took place between August 1979 and October 1980 and employed a crew of 5 (not necessarily full time).



Typical window sill

Economic Analysis:

Capital and Installation Costs

Insulation	$ 27,300
Cladding	30,700
Airfoils	4,800
Labour	85,400
Miscellaneous	4,617
Total:	$152,817

Energy Savings

Pre-retrofit annual energy consumption (average of 77/78 and 78/79)	2,546,250 kWh
Post-retrofit annual energy consumption (average of 80/81, 81/82, 82/83 and 83/84)	(1,835,500 kWh)
Average Annual Savings:	710,750 kWh

Value at 1984
price of steam ($0.0219/kWh): $15,565

Payback Period: 9.8 years.

Note:
The total costs presented above include some items necessary to prevent water leakage but the savings place a value only on the energy saved. Thus, this analysis undervalues this particular project since it was clearly undertaken to both save energy and eliminate water leakage. Indeed, the latter was the prime motivator. The general conclusions to be drawn are that:

- Exterior insulation retrofit appears to have a marginal payback;
- When combined with necessary exterior renovation, it can provide an attractive package.

Availability:

The materials used in this exterior retrofit project are readily available from suppliers of construction materials across Canada. Contractors experienced in the techniques of high-rise exterior cladding may not, however, be available in all areas.

Further Information:

Further information on this and other projects is available from:

- ENEROPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  Room 606, P.O. Box 2009
  55 St. Clair Ave. East
  Toronto, Ontario
  M4T 1M2
  (416)973-1608 or
  1-800-387-0733 (toll free in Ontario)

Detailed information on this project is available from the project manager:

- Dr. Jim Brown
  (re: ENEROPTIONS)
  Director of Physical Plant
  Queen's University
  Kingston, Ontario
  K7L 3N6
  (613) 547-6640

Energy from Wood Waste

FOOTHILL GREENHOUSE LTD. — KETTLEBY, ONTARIO

Technology
- Wood waste (biomass) used in small-scale direct combustion
- Small computer control of greenhouse environment

Demonstration Project Manager:
Foothill Greenhouse Ltd.
R.R. #1
Kettleby, Ontario

Location:
Kettleby, Ontario

Annual Savings: $46,580
61% of pre-demonstration fuel costs

Payback Period: 4.4 years

Applicable to:
- Greenhouses
- Nurseries

Description:

A greenhouse in Kettleby, Ontario burns wood chips and sawdust instead of oil, resulting in energy savings of $46,580 annually.

A small microcomputer controls and monitors heating, ventilation and humidity in the greenhouse — less manpower is needed.

The local availability of abundant supplies of low-cost wood waste make this project economically attractive.

Benefits:

- Overall operating costs, based on burning wood wastes at $30.40/tonne ($27.64/ton) are 39% of those associated with burning bunker "C" oil at $0.178/litre ($0.80/gallon).
- The savings are $46,580 every year, with 428,000 litres of oil displaced annually.
- The computer control of the greenhouse environment improved productivity by providing greater reliability and accuracy with less labour.
- The wood-burning system can effectively utilize lower grade, high moisture content (25%-40%) wood wastes, readily available at a low cost.

Performance:

- A Mottpac boiler was selected because of proven performance records from six other users of the same system. The installation of the boiler proceeded as expected, and the operation and maintenance program progressed without difficulties. The response time of the entire heating system adjusts rapidly to changes in heat demand.
- The boiler tubes remain reasonably clean and there was no sign of creosote build-up during the monitoring period. Cleaning of the system and removal of the ashes does not pose any problems. This is performed once every two months.
- For automatic operation, the feed silo has to be kept full and feed problems are encountered occasionally. The wood handling/feed system requires considerably more attention than an oil burner.

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Technical Details:

Foothill's greenhouse covers an area of 6,040 m^2 (65,000 ft^2). The company grows an exclusive crop of seedless cucumbers, which require a constant temperature of 21° C (70° F). This heat requirement makes fuel the most expensive item for cucumber production. An alternative heat source was needed and, in March 1982, it was decided to use wood waste as a fuel, since it was inexpensive and abundant.

The engineering consultants, Jellicoe Resource Associates Ltd., were engaged to conduct a feasibility study and provide a conceptual design for the demonstration project. Construction and installation were undertaken by the owner of the greenhouses. The monitoring period was September 1982 to December 1982. Prior to monitoring, the system was tested and the material handling system was improved.

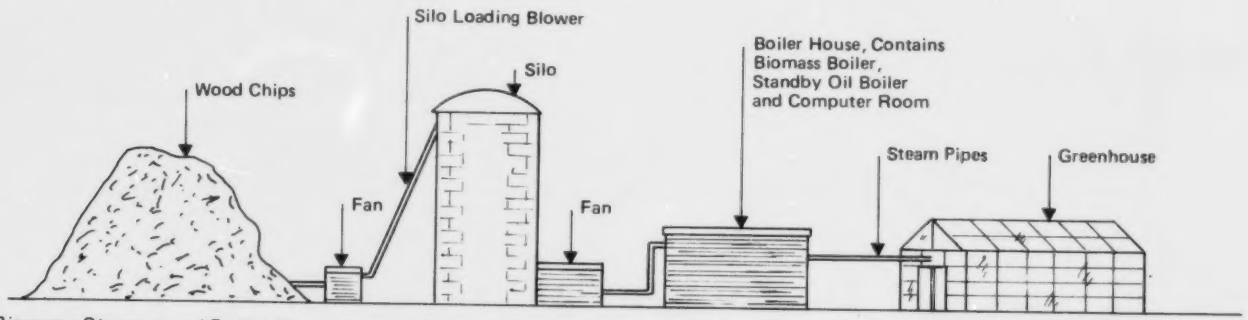
Wood waste, for immediate use, is stored in a steel silo with a capacity of 54-64 tonnes (60-70 tons). Wood chips are blown by a 30 kW (40 hp) fan into the silo. The air used is piped back to the fan, thus controlling dust levels.

The fuel flows by gravity from the silo into a metering container. Then it is transported via a variable speed 15 cm (6 in) auger into the centre of a 7.5 kW (10 hp), 81 cm (32 in) heavy duty fan. The fan blows the material, through a 10 cm (4 in) steel pipe, into the top of the boiler. The feed rate is variable from 180 to 1,000 kg/hr (400 to 2,200 lbs/hr).

The heating system is a 3-pass, suspension burning Mott-pac boiler with a 2,305 kWh (7.9×10^6 Btu/hr) rating. The fuel enters the combustion chamber in a swirling pattern, while an 11 kW (15 hp) fan draws in primary combustion air from below the chamber. The high efficiency of the boiler is attributable to a multi-cyclone grit-arrester. It is designed to trap unburned particles and blow them back into the combustion chamber by way of a venturi system.

Steam is distributed to five climate controlled zones in the greenhouse by means of motorized steam valves. A microprocessor regulates the temperature in each zone by controlling these valves. Motorized vents and exhaust fans are also controlled by the microprocessor. The original boiler was retained as a backup source of heat. The standby heavy fuel oil is kept at 88° C (190° F) by the heat from the wood burner.

The response time of the entire heating system is good, and the boiler is able to adjust rapidly to changes made in the heat demand. This factor is of prime importance to the maintenance of crop production.



Biomass Storage and Boiler House Layout, Foothill Greenhouse Ltd.

Economic Analysis:

Capital Cost:

Item	Cost
Boiler	$103,000
Silo	43,000
Filler system	14,000
Stack	3,500
Microprocessor	26,500
Insulation	4,000
Electrical	6,000
Miscellaneous	3,000
Total Capital Cost*	$203,000

*(Expenditures for construction and installation labour are not included as the owner did the work himself.)

Operating Cost Comparison (Wood at about 10% moisture content):

- 1 tonne (1.1 tons) of wood waste was found to supply the same heat output as 475 litres (104.5 gallons) of bunker "C" oil.
- Approximately 909 tonnes (1,000 tons) of wood waste is required annually.
- Wood waste costs $30.40/tonne ($27.64/ton) while oil costs $0.178/litre ($0.80/gallon).
- Annual operating cost comparison:

Item	Wood System	Oil System
Fuel	$27,640	$76,000
Electricity	1,020	240
Labour	1,000	—
Total	$29,660	$76,240

- Annual savings: $46,580

Simple Payback Period: 4.4 Years.

Availability:

The technology and suppliers of equipment are available throughout Canada in major centres. Experienced consultants should be retained to conduct feasibility and design studies. The local availability of a wood waste supply at a reasonable price is a key factor in determining the attractiveness of this approach.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  Room 606, P.O. Box 2009
  55 St. Clair Ave. East
  Toronto, Ontario
  M4T 1M2
  (416) 973-1608 or
  1-800-387-0733 (toll free in Ontario)

Information on the demonstration project is also available from the consultant:

- Biomass Thermal Utilities Inc.
  (re: ENEROPTIONS)
  1665 Kipling Ave.
  Weston, Ontario
  M9R 2Y4
  (416) 242-5166

Low Temperature Flue Gas Heat Recovery System

JOHN DEERE LTD. — WELLAND, ONTARIO

Technology:
Recovery of low-grade heat from flue gas

Demonstration Project Manager:
Energy Coordinator
John Deere Limited
Welland, Ontario

Location:
Welland, Ontario

Annual Savings: $35,370
7.1% of boiler fuel consumption

Payback Period: 3 to 7 years
(Depending on application)

Applicable To:
Existing industrial/commercial/institutional natural gas firing facilities (boilers, dryers, heaters) with flue gas temperatures above 200° C (392° F) and serving substantial low temperature heat demand, such as space heating.

These conditions may exist in:

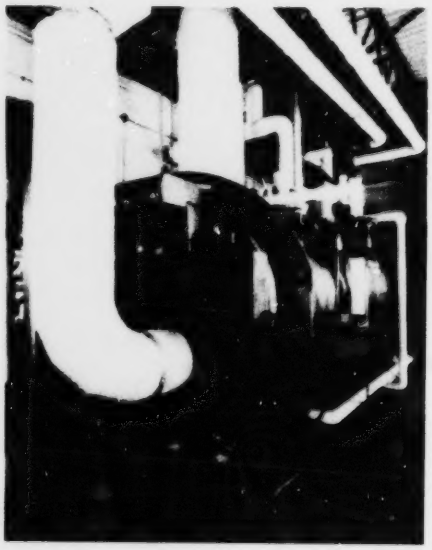
- Heavy equipment manufacturing
- Food processing
- Textile manufacturing
- Recreational and sports facilities
- Hospitals
- Pulp and paper facilities
- Industrial washing and cleaning operations
- Universities

Description:
John Deere Limited saw opportunities to reduce its energy costs by recovering low-grade waste heat from flue gas at its Welland Works.

A Beckett Heat Recovery System, a Canadian invention, developed and produced by Blenkhorn and Sawle Limited, was installed and monitored for seven months.

This innovative system reduces flue gas temperature close to, but safely above the dewpoint level, thus avoiding equipment corrosion problems.

A standard firetube boiler is used as a heat exchanger to transfer reclaimed heat energy to hot water for space heating and indirectly for preheating boiler feedwater in winter months. In the summer the unit serves as a compact, economical steam source for the plant's reduced requirements.



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Benefits:

- The system can save up to 300,000 m^3 (10,600 Mcf) of natural gas a year.
- Equipment corrosion problems are avoided as the flue gas remains above its dewpoint.
- Upgrading the heating of the machine shop and elimination of negative pressure in the building improves the comfort level for employees.

Performance:

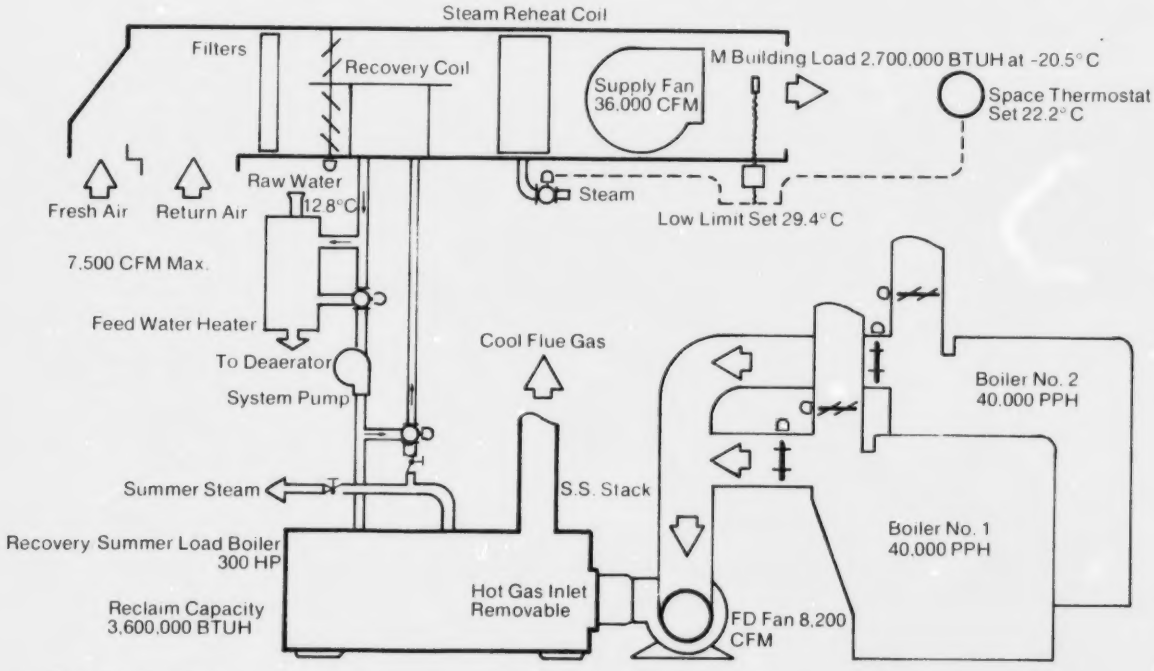
- The economic performance would have improved significantly if there had been full utilization of the system.
- The satisfactory performance of the system was verified during separate winter and summer operating periods, totalling seven months. The heat recovery system was not required to operate at its full capacity during these periods due to reduced plant activity.
- In winter mode, the monitored energy savings were 6.9% of total boiler fuel consumption. The manufacturer claims potential savings of 8.5% can be achieved.
- In summer mode, fuel savings of 18.2% were achieved by not using the plant's main boilers. The monitored efficiency of the unit operating as a summer boiler was 82%.
- No problem has been encountered with scaling or corrosion of the installation.
- Initially, during peak steam demand, the heat recovery system could not handle the quantity of flue gas generated by the original steam-producing boiler. This caused excessive backpressure in the boiler's firebox. To combat this problem, an additional damper control system with a pressure sensor in the firebox was installed. When excess pressure is detected, the new controller overrides other damper controls, allowing the stack damper to open and relieve the excess pressure.

Technical Details:

John Deere Limited has a 65,065 m^2 (700,000 ft^2) manufacturing plant at Welland, Ontario. An in-house energy management team analyzed a number of opportunities for using reclaimed heat in the plant. Two applications were selected: space heating (involving make-up air tempering for a remote 3,532 m^2 (38,000 ft^2) machine shop), and the preheating of boiler feedwater.

The Beckett Heat Recovery System, shown in the schematic diagram, was selected for its capability to reclaim waste heat from flue gas while controlling the reduction of flue gas temperature to avoid the corrosion-causing dewpoint range.

This unit (Series 2002), which uses a standard firetube boiler as the system's heat exchanger, was commissioned in January of 1983. Its performance was monitored as a summer load boiler between June and September 1983, and as a heat recovery unit between November 1983 and January 1984.



John Deere Welland Works

Beckett Heat Recovery System Series 2002

Hot flue gas, in the range of 200° C to 300° C (400° F to 572° F), is drawn through the breeching bypasses connected to the existing plant boilers by a high temperature forced draft fan at the rate of 232 m^3/min (8,200 cfm).

The inlet spool between the fan and the front of the boiler is removable to permit the installation of a gas burner for making steam during the summer months.

The recovery/summer boiler is a modified 2.9 x 10^6 W (300 hp) firetube boiler with a four-pass heat exchanger which provides a heat transfer surface of 0.5 m^2 (5 ft^2) per boiler horsepower.

When the unit operates in the heat recovery mode, its maximum reclaim capacity is 1,055 kW (3.6 x 10^6 Btu/hr) and the flue gas temperature is reduced to 66° C (150° F) thus providing a 7° C (13° F) margin over the dewpoint.

A stainless steel stack with internal condensate collection ring and drain is provided. The section of the stack above the roof is thermally insulated.

The heated water from the recovery boiler is pumped into a coil in a single 1,020 m^3/min (36,000 cfm) heating/ventilating unit. This unit, installed in the machine shop as part of this project, employs a system of spiral ducts for even heat distribution.

A plate-type heat exchanger extracts heat from the return flow from the machine shop to preheat feed water to the main boiler whenever excess heat is available. This maximizes heat recovery from the flue gas. The maximum heat recovery rate is 400 kW (1.35 x 10^6 Btu/hr).

The primary loop of the dual function temperature control system of the heat recovery unit regulates the flue-gas bypass dampers. The dampers divert the flue gas around the recovery boiler if the water temperature exceeds the set point.

The secondary loop has a controller that positions a three-way valve to bypass water around the recovery boiler if the boiler's water temperature drops below a fixed set point of 60° C (140° F). This holds the flue gas exit temperature at 66° C (150° F) and provides a safety margin of 7° C (13° F) above the dewpoint to avoid condensation and corrosion.

From May to September, when steam demand is low, the recovery boiler is converted to a gas-fired high pressure steam boiler to produce the plant's reduced steam load, which averages 3,402 kg/hr (7,500 lbs/hr). This permits the plant's main boilers to be shut down during this low-demand period.

After almost two years of operation, the low-grade heat recovery system installation at the John Deere Welland plant has proven itself to be viable and economical. Monitoring of the system shows improved economies can be achieved if there is a steady requirement for recovered heat in the 66° C to 93° C (150° F to 200° F) range.

A Beckett Heat Recovery System was also installed in the steam plant of the Welland County Hospital. Significant energy savings were reported. During a monitored three-month period, the hospital reduced energy consumption by 17.4%, a saving of $10,331. Since the system was installed, the annual consumption of natural gas has been reduced by approximately 20% and a payback period under three years was attained. The success of this project resulted in Blenkhorn and Sawle Limited receiving the ASHRAE Energy Award, in the new process category, "in recognition of outstanding achievement in the design of energy efficient buildings".

A similar system, including a heat recovery boiler, has been installed at the Port Colborne General Hospital. Flue gas heat is recovered for the building's space heating requirements.

At Carleton University, in Ottawa, a system was installed to preheat makeup water and combustion air for the main boiler.

Economic Analysis:

Since this technology is primarily applicable to retrofit situations, the economics are highly dependent upon site specific factors. The direct costs and estimated annual savings based on monitored results are detailed below. The annual savings would have been greater if the John Deere plant had been operating at full capacity and if there had been a larger demand for the recoverable heat.

Project Capital Costs:

Recovery/summer boiler system	$148,734
Makeup air/heating system	92,656
Total Installed Cost	$241,390

Annual Operating Costs*:

Pre-demonstration fuel costs (3,116,981 m^3 natural gas @ $0.159/$m^3$)	$495,600
Post-demonstration fuel costs (2,894,528 m^3 natural gas @ $0.159/$m^3$)	(460,230)
Net Annual Savings	$ 35,370

Simple Payback Period: 6.8 years.

*Maintenance costs not available

Availability:

The demonstration unit, a Beckett Heat Recovery System Series 2002, was developed, supplied and installed by Blenkhorn and Sawle Limited of St. Catharines, Ontario.

Well-qualified electrical-mechanical contractors should be selected to install such systems.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  55 St. Clair Ave. East
  Toronto, Ontario
  M4T 1M2
  (416) 966-8480 or
  1-800-268-1197 (toll free in Ontario)

Information on the demonstration project is also available from the supplier:

- Blenkhorn and Sawle Ltd.
  (re: ENEROPTIONS)
  P.O. Box 3020
  100 Grantham Ave.
  St. Catharines, Ontario
  L2R 7B9
  (416) 684-9251
  or 1-800-263-7242 (toll free within 416 area)

ENER OPTIONS CASE STUDY

ONT 47

Water Source Heat Pumps

VALLEY EAST RECREATIONAL COMPLEX — SUDBURY, ONTARIO

Technology:
Heat recovery using groundwater source heat pumps

Demonstration Project Manager:
The Corporation of the Town of Valley East
P.O. Box 430
Valley East, Ontario

Location:
Valley East, Ontario

Annual Savings: $22,446
67% of electrical resistance heating costs

Payback Period: 6.7 years

Applicable to:
New buildings and buildings where existing heating systems require replacement in areas with well-established groundwater supplies

Description:
A sports complex north of Sudbury, Ontario estimate that their groundwater source heat pump is three times more efficient than conventional electric heating. They save over 60% in space and pool heating and air conditioning costs each year.

The groundwater source heat pump is installed at the new Valley East Recreational Complex. Groundwater is pumped to heat exchange/heat pump units. Extracted heat is transferred to building and space heating loads. The cooled water is returned to the aquifer through a recharge well. The cooling mode reverses the process, transferring building heat to the aquifer.

Benefits:
- Annual energy savings, in comparison to a conventional electric system, are estimated at 580,000 kWh or $22,400 per year.
- The groundwater acts both as a heat source for winter space heating and as a heat sink for summer cooling and air conditioning.

Performance:
- Installation and operation have proceeded as expected. Monitoring has been ongoing since January 1984.
- The change in the temperature of the water returned to the aquifer is minimal.
- Early in the operation, the recharge well screen was blocked with silt that came from the supply well. This problem has since been solved by drilling a new supply well and redeveloping the recharge well.
- Some custom fittings and components were required. Examples include the temperature parameter controls for the heat pump and the use of glycol to prevent ice formation in the evaporator.

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Technical Details:

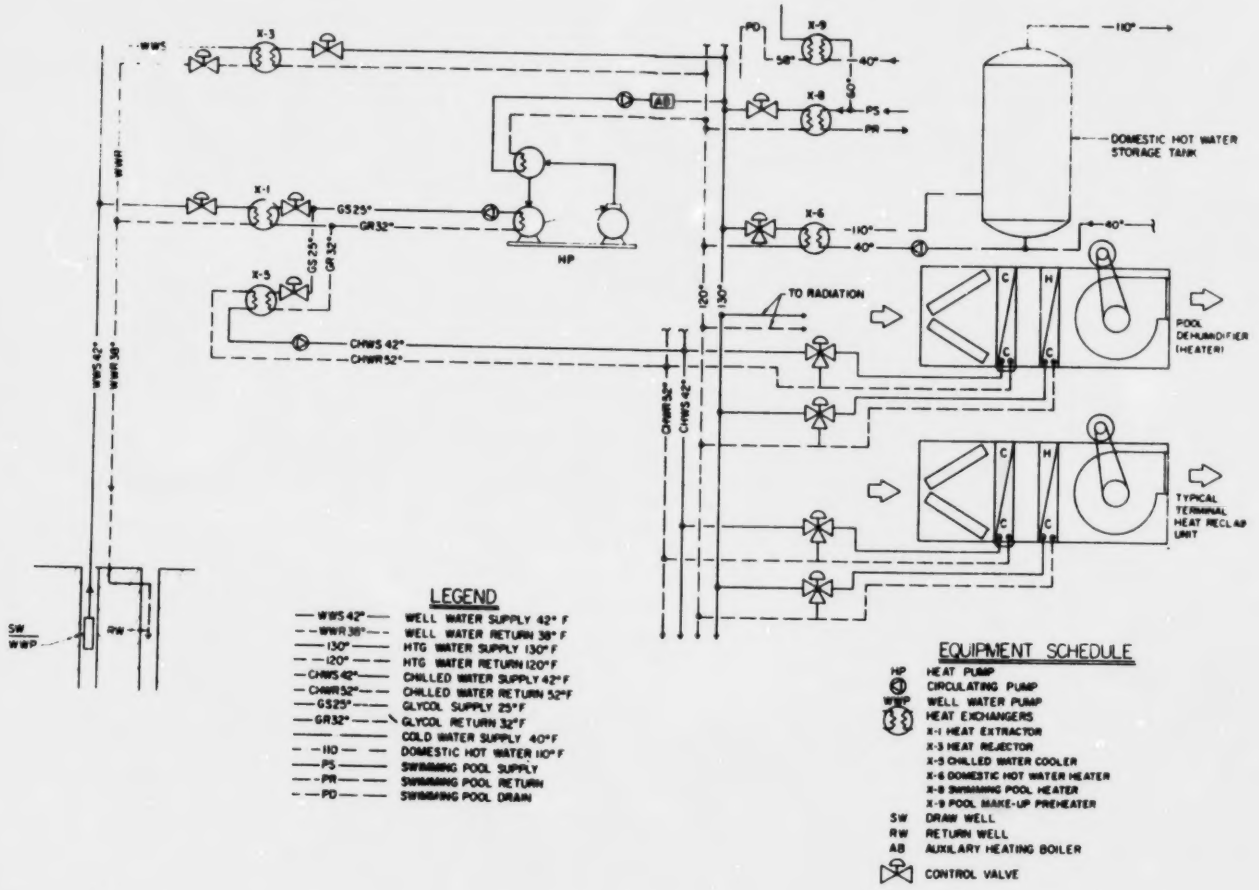
The Valley East Recreation Complex, just north of Sudbury, demonstrated the cost effectiveness of a groundwater source heat pump for space and pool heating and for cooling in the summer. The system is illustrated in the schematic diagram.

Water is pumped at a rate of 1,135 litres per minute (250 gpm) from a 15 m (49 ft) deep supply well, to heat exchanger/heat pump units. It is then returned to a discharge well approximately 91 m (300 ft) away.

Heat is transferred via the heat exchangers, through two glycol loops, to two Durham-Bush heat pumps. Each heat pump has two compressors, each rated at 91.4 kW (26 tons), for a total capacity of 366 kW (104 tons).

The aquifer feed water is cooled from 5.6° C to 1.7° C (42°-35° F) The heat pumps use the extracted heat to raise the output temperature to 54° C (129° F) for space, pool and hot water heating.

The same heat pump/heat exchanger units are used to cool the building in summer by reversing the process. The groundwater acts as a heat sink in this case.



Economic Analysis:

The nature of this technology makes it attractive for new facilities or facilities where the existing heating system is being replaced. The following analysis illustrates the economics of the heat pump system in comparison with the estimated cost of a conventional electric system.

Capital Cost Estimate

• Heat Pump System	$330,000
• Conventional System	(180,000)
• Cost over and above conventional system	$150,000

Annual Building Heating Cost Estimates

Conventional electric system (870,000 kWh @ $0.0387/kWh)	$ 33,669
Innovative Heat Pump system (290,000 kWh @ $0.0387/kWh)	(11,223)
Estimated net annual energy savings (580,000 kWh @ $0.0387/kWh)	$ 22,446

Estimated simple payback period on additional cost: 6.7 years.

Availability:

The system uses standard refrigeration components which are supplied and distributed on a national basis. Some custom fittings and modifications may be necessary. The services of an experienced engineer are likely required.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  55 St. Clair Ave. East
  Toronto, Ontario
  M4T 1M2
  (416) 966-8480 or
  1-800-268-1197 (toll free in Ontario)

Information on the demonstration project is also available from the consultant:

- Piotrowski Consultants Ltd.
  (re: ENEROPTIONS)
  1281 Cassells Street
  North Bay, Ontario
  P1B 4B8
  (705) 472-2536

ENERGY OPTIONS CASE STUDY

ONT 48

Automatic Wood-Fired Boiler

GRENVILLE CHRISTIAN COLLEGE — BROCKVILLE, ONTARIO

Technology:
Automatic wood (biomass) burning system, using a direct combustion boiler

Demonstration Project Manager:
Grenville Christian College
P.O. Box 610
Brockville, Ontario

Location:
Brockville, Ontario

Annual Savings: $75,000
68% of the pre-demonstration fuel costs

Payback Period: 4.4 years

Applicable to:
Facilities with space heating using hot water radiators, and where a secure supply of wood is available:

- Schools/Colleges
- Hospitals
- Remote communities

Description:
Ontario's first large, fully automated institutional wood heating system was started up in the fall of 1982 at Grenville Christian College in Brockville.

The system is designed to produce 5.7×10^6 L/hr (1.26×10^6 gals/hr) of hot water at a temperature of 110° C (230° F). The wood burning unit consists of an ignition cell, a combustion cell and a fire-tube hot water boiler.

The hot water generated by the boiler is pumped under a pressure of 172.4 kPa (25 psi) to the College to provide space heating through hot water radiators. In addition, hot water is circulated through a heat exchanger to provide hot tap water. The new system has sufficient capacity to meet anticipated growth of the College over the next 15 years.

Eventually, the College intends to supplement its purchased wood supply by producing wood chips from its own hybrid poplar plantation.

Benefits:

- An estimated average annual savings of $71,000 in fuel costs can be realized at current prices. The actual savings during the monitored year were $74,929 due to an increase in oil prices and a decrease in the cost of wood fuel.
- This fuel substitution demonstration showed that approximately 1,000 dry tonnes (1,100 dry tons) of wood chips can replace 345,000 litres (76,000 gals) of #2 Bunker fuel oil in an average year.
- Substitution of wood chips for a non-renewable fuel has proven feasible for the supply of all hot water to the College.

ENERGY OPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENERGY OPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Performance:

- Downtime due to system failure was only 149 hours during the monitoring period. This amounted to an equipment availability of 98% which, considering the type of fuel used, indicates a high degree of reliability.
- Boiler efficiency was measured between 52% and 72% using heat loss method. The average wood burning efficiency was computed at 66%.
- Annual fuel savings, during the monitoring period, was 5.5% higher than predicted savings, largely due to increased oil prices in 1983.
- Boiler particulate emissions were within limits imposed by current regulations. SO_2 emissions were well below provincial impingement standards.
- The installation of refractory material in the combustion cell was below expectations. It should have been installed by a specialist. Consequently, major renovations were required before start-up.
- The facility performed as well as expected. During the monitoring period however the following problems were cited:
  - — The induction fan system was engineered improperly and required redesigning and replacement.
  - — Bridging and jamming in the augers was a constant problem due to the stringy nature of the wood fuel. The use of more costly high quality slab chips would eliminate this problem.
  - — It is difficult to maintain good combustion during warm weather conditions due to low demand. Wet or dirty fuel creates problems during these periods and increases operator maintenance time.
- In general, during cold weather conditions the system operates with high efficiency and atmospheric emissions are lower. The efficiency drops off with lower load requirements so the system is shut down during the summer.

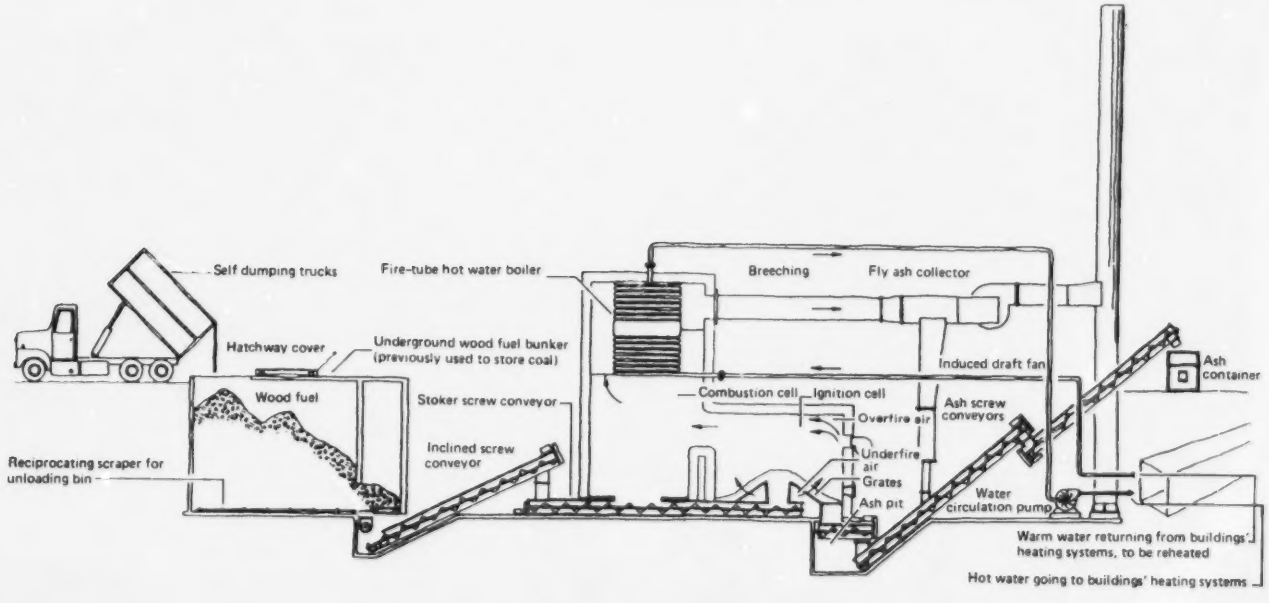
Technical Details:

- Grenville Christian College installed a large Anga-Varme 5.3 GJ/hr (5.0×10^6 Btu/hr) fully automated institutional wood heating system, as illustrated in the schematic diagram, in the fall of 1982 and closely monitored performance from November 1982 to December 1983.
- Stack emission testing was conducted at regular intervals by Envirocon Eastern Ltd.
- Wood fuel delivered to the College by independent contractors is weighed on arrival. The material must conform to specifications limiting particle size and moisture content. A sample is removed and analysed for moisture control and payment is based on its dry weight. The wood fuel is dumped into an underground storage bunker which holds one week's supply. This bunker is equipped with a reciprocating scraper to unload the bin. The fuel flows onto a system of inclined and horizontal screw conveyors to feed the furnace.

The wood burning unit consists of an ignition cell, a combustion cell and a fire-tube hot water boiler. A horizontal stoker screw conveyor moves the fuel into the ignition cell. On its way to the ignition cell the wood is exposed to the combustion cell where hot gases and radiation vaporize a considerable amount of its moisture content.

In the ignition cell the fuel is forced upward through an opening where it spreads over a number of sloping grates arranged in a circle. Air is injected under the grates to remove more moisture from the fuel, to assist fuel ignition and also to cool the grates. Air is also introduced above the grates by an overfire fan, mixing with the hot gases as they enter the combustion cell. The narrow passage at the entrance to the combustion cell causes the gases to accelerate.

The burning process is completed in the combustion cell. Here, the velocity of the gases decreases. This causes larger unburnt particles to drop into the stoker screw conveyor which returns them to the ignition cell along with fresh fuel.



The furnace reaches a temperature of 1,900° C (3,452° F).

Spent combustion gas is drawn through the boiler and breeching by an induced draft fan into a fly ash cyclone collector. Solid particles in the gas stream are removed and fall back onto an inclined ash screw conveyor. The cleaned gases are decelerated and pass out through the stack. Ash is removed manually every 3 to 4 days by raking out the ash pits provided on each side of the ignition cell. A system of screw conveyors automatically removes the ash from the ash pits to an ash disposal container outside the building. The 635 kg (1,400 lbs) of ash generated per week is used on school roads in the winter and in the garden as fertilizer in the summer.

The hot water generated by the boiler is pumped to the College buildings through pipes located in underground tunnels. The College buildings are heated by this hot water passing through radiators. The cooled water circulates back to the boiler house and is pumped through the boiler for reheating. The hot water is also circulated through a heat exchanger to provide domestic hot water.

The temperature of the water leaving the boiler is monitored to automatically control boiler output. When the temperature of the outlet water falls to and below 86° C (187° F) the boiler goes into the high fire mode, and when the water rises to and above 92° C (198° F) it switches from high fire to low fire. The duration of operation of the induced draft fan, stoker screw conveyor and the overfire fan depends on timers associated with high fire or low fire operation. The boiler adjusts to different loads by varying the duration of each firing cycle.

Economic Analysis:

Actual energy costs were monitored during 1983. In order to estimate annual savings, an estimate of what 1983 costs would have been (using oil) was developed. This analysis is as follows:

Project Capital Cost

Wood burning system	$177,938
Labour	149,305
Total Installed Cost	$327,243

Annual Savings:

Equivalent 1983 oil cost — 341,745 litres @ $0.321/litre	$109,700
Actual 1983 Energy Costs	
— 665 oven dry tonnes wood @ $37/tonne	24,605
— 29,660 litres of oil @ $0.321/litre	9,521
— Electricity	645
Total 1983 Energy Costs	34,771
Annual Savings	$ 74,929

Simple Payback Period: 4.4 Years.

If the system was used to its full capacity, payback could be as little as 1.5 years. The College was forced to an oversized unit, since none were available in the required size.

Availability:

- The unit was built in Canada according to a Swedish design, under the direction of Anga-Varme (Canada) Ltd. of Thunder Bay, Ontario. Other suppliers of wood burning systems may provide similar equipment.
- A reputable and qualified consulting engineer should be selected to supervise the general contractors. The supplier should maintain major servicing of the equipment after installation.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  Room 606, P.O. Box 2009
  55 St. Clair Ave. East
  Toronto, Ontario
  M4T 1M2
  (416) 973-1608 or
  1-800-387-0733 (toll free in Ontario)

Energy Efficient Concrete Block Curing

TCG MATERIALS LIMITED — BURLINGTON, ONTARIO

Technology:
Bubble curing for concrete blocks

Demonstration Project Manager:
TCG Materials Ltd.
P.O. Box 5000
Burlington, Ontario
L7R 3Y8

Location:
Burlington, Ontario

Annual Savings: $261,000
90% compared to the old process

Payback Period: 2 years

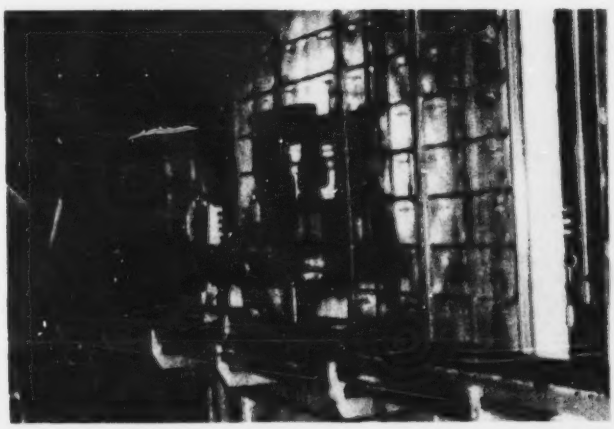
Applicable to:
- Large-scale concrete block manufacturers
- Building materials manufacturers
- Ceramic producers

Description:
An impressive 90% saving in energy costs prompted TCG Materials Ltd., cement block manufacturers, to use a new curing process at their Burlington, Ontario plant. Not only did they save energy, but productivity has been greatly increased and the concrete blocks are of superior quality, colour and strength.

The new bubble cure continuous warm vapour system replaced the traditional energy-intensive autoclave process.

Bubble curing releases large amounts of water vapour and heat into the kiln atmosphere, making an excellent curing environment. This continuous evaporative process maintains constant humidity uniformly throughout the kiln with very little energy loss.

With the outdated autoclave system, lengthy start-up and shut-down times were necessary to load and unload the kilns. Large amounts of thermal energy, manpower and time were lost each cycle. It was virtually impossible to achieve the exact temperature and curing conditions for each batch; so consistency of quality was affected. Working conditions were also hazardous near the pressurized autoclaves.



Benefits:
- Extremely high annual energy savings — estimated savings are over 90% of pre-demonstration natural gas consumption.
- Elimination of high pressure steam means less hazardous working conditions; lower insurance costs; reduced heat losses; lower noise levels; and reduced equipment maintenance and replacement costs.
- Automated concrete block handling and kiln loading results in reduced chipping, breakage and waste, and increased productivity.
- The totally enclosed bubble kiln maintains constant temperature and humidity to promote even curing and stronger blocks of more consistent colour.

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Performance:

- The bubble cure system uses an energy input of only 790 KJ (750 BTU) per block while the autoclave unit required 9,500 to 10,550 KJ (9,000 — 9,500 BTU) per block. This efficiency yields an annual saving in gas of $261,000.
- The technology performed as planned and has produced excellent results:
  - superior strength is achieved through a uniform and longer curing process
  - elimination of unnecessary handling has led to virtually flawless quality in each block produced
  - styles, shapes and colours are consistent and reproduceable over long production runs
- this technology has worked well in the U.S. for a number of years and has now been demonstrated successfully in Canada.

Technical Details:

In April 1983, TCG Materials Ltd. installed a BECO ABC "Bubble Aire" system at its cement block manufacturing plant in Burlington, Ontario. The bubble cure system as illustrated in the schematic diagram was developed in the U.S. in 1977 and is now used by more than 40 U.S. concrete block producers.

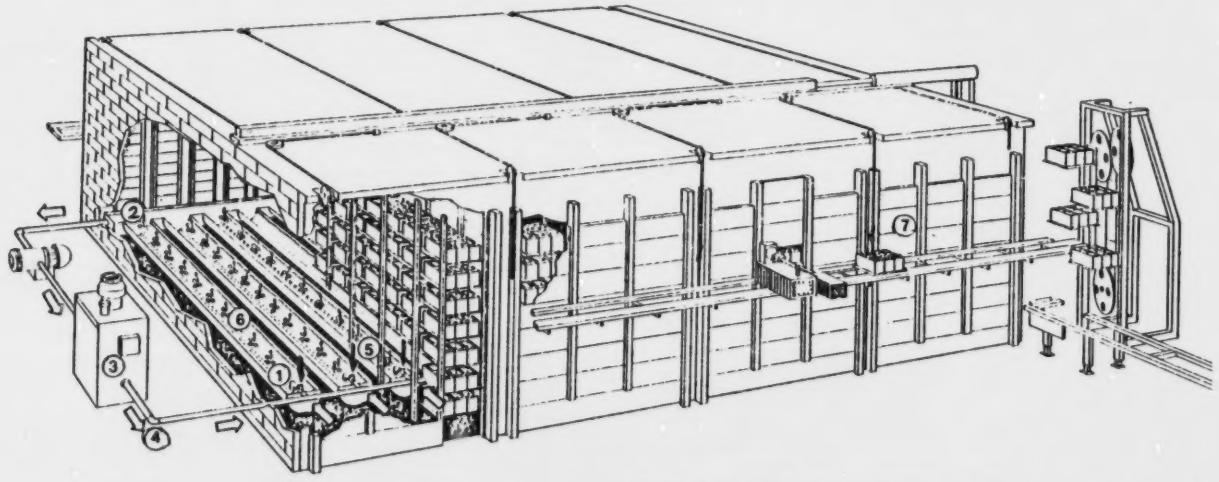
The technology was selected to replace an outdated, semi-automatic autoclave system that required high pressure steam and large amounts of heat. This heat was vented to atmosphere each time the autoclave was opened at the end of the curing cycle.

The TCG plant renovation and system installation took 7½ months and Contram Manufacturing (1982) Ltd. supplied the "Bubble-Aire"equipment.

The fully enclosed kiln is loaded automatically from conveyor belts, one pallet at a time, through insulated pigeon-hole doors. Each block is in the kiln curing process within two minutes of being formed.

In the bubble cure kiln constant and uniform curing conditions exist for the blocks on all shelf levels. They all receive exposure to ideal curing conditions of continuous, very high humidity and even temperature.

Under each shelf bay and running the length of the kiln, are hot water troughs. Water flows into a perforated copper pipe in each trough and is aerated with kiln air injected by a venturi. The effervescent water flows from the pipe into the trough. Air bubbles rise to the top and agitate the water's surface, transferring water vapour and heat into the kiln atmosphere for curing. After releasing its bubbles, the water flows out of the undershelf troughs into a common collector trough at the rear of the kiln. It is then pumped back through a water heater to begin its cycle again.



Heat and moisture Air into venturi tubes Water flow

Operation of the Bubble Cure System

Under each bay of the shelves there is a pan filled with hot water (1). Each pan runs the length of the kiln and is attached to the collector pan (2) at the rear of the kiln. Hot water circulates through the pans into the collector pan and then is pumped through a hot water heater (3) back to the individual pans. As the newly heated water (4) enters each pan through a venturi, it is aerated by injected kiln air (5) and flows through a long perforated pipe (6) at the bottom of the pan. Bubbling water escapes through the holes in the pipe, rises and disturbs the surface of the water. This bubbling releases heat and moisture in the form of water vapour (not steam) to the kiln atmosphere for curing. Bubble curing only works in a totally enclosed kiln such as BECO ABC and BECO Pigeon-Hole Kiln Doors (7) make possible.

Economic Analysis

Project Capital Cost

Capital Equipment	$1,389,000
Installation Cost	625,000
Total Installed Cost	$2,014,000

Annual Fuel Cost

Pre-demonstration fuel cost (1.66×10^6 m^3 natural gas at $\$0.17/m^3$)	$ 282,000
Post-demonstration fuel cost (0.123×10^6 m^3 natural gas at $\$0.17/m^3$)	$ 21,000
Annual Fuel Saving	$ 261,000

Payback Period

When improvements in productivity and reduced maintenance costs are taken into account, the overall payback period is estimated at approximately two years.

Availability:

- The demonstration unit was designed by Builders Equipment Co. of Phoenix, Arizona. Contran Manufacturing (1982) Ltd. of London, Ontario, has the licence to manufacture the Bubble Cure system in Canada.
- TCG Materials Ltd. and Contran Manufacturing (1982) Ltd. were responsible for site engineering and installation. A local building contractor was hired to undertake plant renovation work.

Further Information:

Further information is available from:

- ENEROPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  Room 606, P.O. Box 2009
  55 St. Clair Ave. East
  Toronto, Ontario
  M4T 1M2
  (416) 973-1608 or
  1-800-387-0733 (toll free in Ontario)

Information on the demonstration project is also available from the supplier:

- Contran Manufacturing (1982) Ltd.
  (re: ENEROPTIONS)
  875 Florence St.
  London, Ontario
  N5W 2M6
  (519) 455-5604

Computerized Energy Accounting

HUDSON'S BAY COMPANY

Technology:
Mini-computer software which identifies inefficient energy use in buildings

Demonstration Project Manager:
Mr. Fred Bergman
Energy Conservation Manager
Hudson's Bay Company
2 Bloor Street East
Toronto, Ontario
M4H 3H7
(416) 964-4820

Location: Southern Ontario

Annual Savings: $4,250 in managerial time (not including energy savings identified by the system)

Payback Period: Less than one year

Applicable to: Commercial buildings

Description:
The Hudson's Bay Company is managing its energy use better and paying less for more complete information by changing its system of monitoring energy use in 65 buildings from a manual to a mini-computer system. The Commercial Energy Monitoring and Accounting System (CEMAS), a computer management information system, provides energy accounting and energy analysis services to commercial buildings. The system, as demonstrated in this project, differs from many other building energy analysis systems, in that:

- It is designed to be used by the building owner/manager/operator as opposed to specialized consulting engineers.
- It is accessible at several levels — managerial, technical, clerical.
- It performs routine monitoring and accounting functions as well as complex technical analysis.
- Reports are produced on demand at a local terminal in English or French and in metric or imperial units.

The system analyzes past and current energy use allowing managers to identify potential energy savings and areas where a more detailed computerized audit is justified. It also allows the user to monitor the results of energy improvement investments using before and after retrofit cost and performance data. The computer-aided audit on three Hudson's Bay Company buildings, which examined areas of inefficient energy use and improvements in scheduling, operations, building equipment, and building shell, have identified potential savings that range up to 50%.

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Benefits:

- Enables the building management to compare and track energy use in any number of buildings regardless of variations in billing dates and calculation methods, units, methods of delivery, changes in weather patterns and building size and use.
- Provides a low-cost method of determining the areas which will give the greatest energy savings per dollar invested.
- Provides computer-aided simplified audit procedures for detailed heat loss savings analysis.
- Can be used by in-house personnel without extensive training using IBM PC XT or compatible personal computer, or a main frame which supports Fortran 77.
- Enables user to check energy bills quickly and thoroughly for mistakes.
- Provides a tool for comparing various available rate structures when negotiating with utilities.

Performance:

Beginning in September 1983, CEMAS was used to monitor energy use in 65 buildings owned by the Hudson's Bay Co. Monthly reports detailing energy use were successfully produced for all buildings.

Three of the Hudson's Bay buildings were then selected for the detailed energy audit procedure. The following energy savings were identified:

- $1,000,000 or 50% for a multi-storey 91,695 m^2 (987,030 ft^2) older department store.
- $50,000 or 12% for a 69,213 m^2 (745,030 ft^2) warehouse built in 1960.
- $6,000 or 5% for a 2 storey 11,520 m^2 (124,000 ft^2) department store built in 1981 in a shopping mall.

Appropriate retrofits are underway. The only problem encountered in the operation of the system was in the incompatibility of the Hudson's Bay computer hardware with the remote on-site computers. This was solved by modifying the CEMAS software.

Technical Details:

The CEMAS software can be purchased and run on an IBM compatible personal computer or it can be leased on a central computer and communicated with from anywhere in Canada. The latter option requires the user to have a video display terminal, a telephone data coupler and a printer. Communication with the computer is through the DATAPAC network.

CEMAS consists of four modules: energy monitoring and accounting, past energy use analysis, inventory of energy using equipment and more detailed analysis for technical analysis. The last module calculates energy gains and losses and potential savings if modifications are made to the building. Included are: infiltration, ventilation and transmission losses and solar gain.

Economic Analysis:

Using a manual system, Hudson's Bay Company annually used over 20 days of managerial time as well as clerical time to account for energy used quarterly, annually (six months after year-end), and by exception.

Using CEMAS, annual savings are: $4,250

One-time software purchase
(lower for fewer buildings): $4,000

Thus, payback is less than one year not including the energy savings identified, the additional managerial productivity or the initial start-up costs.

Availability:

Similar systems may be available from other sources across the country. CEMAS can be obtained from:

- Mr. George Hollingsworth
  Product Manager
  Arbour Control Engineering
  53 Queen Street
  Ottawa, Ontario
  K1P 5C5
  (613) 563-9044

Further Information:

For further information contact:

- ENEROPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  55 St. Clair Avenue East
  Room 606, P.O. Box 2009
  Toronto, Ontario
  M4T 1M2
  (416) 973-1608 or
  1-800-387-0733 (toll free in Ontario)
- Mr. Fred Bergman
  Energy Conservation Manager
  Hudson's Bay Company
  2 Bloor Street East
  Toronto, Ontario
  M4H 3H7
  (416) 964-4820

Vertical Loop Ground-Source Heat Pump

ARC RENTAL SERVICE LIMITED — TORONTO, ONTARIO

Technology:
Ground-source heat pump

Demonstration Project Manager:
Mr. George Inward
Arc Rental Service Ltd.
9 Taymall Avenue
Toronto, Ontario

Location:
Toronto, Ontario

Annual Savings: $6,100
66% of conventional energy costs

Payback Period: 4.4 years

Applicable to:
New or replacement heating systems in commercial, industrial and institutional buildings.

Description:
In the fall of 1982, Arc Rental Service Ltd. of Toronto, Ontario installed the first vertical loop ground-source heat pump system in Ontario. The system supplies space heating and cooling for two industrial buildings previously heated with oil.

A vertical loop ground-source heat pump system extracts heat stored in the ground by circulating a heat transfer solution through a series of closed-loop polyethylene pipes buried in vertical holes. Heat is returned to the ground during the summer months.

Such systems have been used successfully in Sweden for 20 years, and are widely used in Europe and the United States.

The installed Cantherm system removes heat from the earth using a circulated glycol solution and supplies constant space heat to the buildings via two heat pumps. In summer, cooling is achieved through a passive fluid circulation system.

Installing vertical loops in the ground at depths of between 83 m and 107 m.

Benefits:

- Annual energy savings of approximately $6,100 were realized from the installation of the heat pumps.
- The passive cooling cycle increases summer comfort levels at substantial cost savings over conventional systems.
- Actual annual savings from both the heat pump and increased insulation levels are between 65% and 75%.
- A ground-source heat pump can also supply the domestic hot water requirements while an air-source heat pump usually does not. An additional advantage over the air-source is the higher seasonal coefficient of performance (COP) of 2.7 of the ground-source. The more constant temperature of the ground throughout the year gives the ground-source heat pump this higher year-round efficiency.

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- With a ground-source heat pump, the uncertainties of developing suitable supply and return wells associated with a groundwater-based heat pump are avoided.
- The life expectancy of ground-source heat pumps is longer than air-source heat pumps. (Air-source heat pumps are subjected to many more starts due to more frequent and wider fluctuations of the ambient air temperature.) A ground-source system operates with a virtually constant source temperature and its operation is stable over long periods of time, reducing wear and tear.
- Each of the two installed heat pumps is capable of annually extracting heat from the ground equivalent to the heating value of 120 barrels of oil.

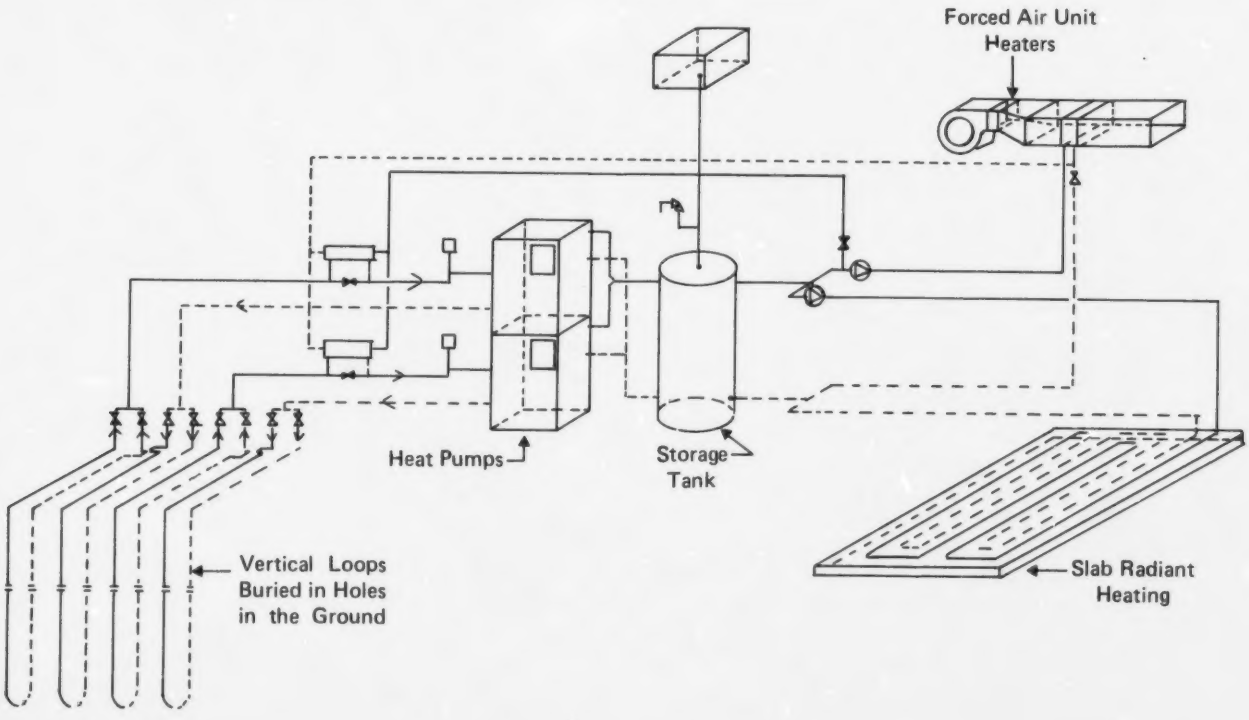
Performance:

- The Cantherm heat pump system began operation in November 1982 and has continued to operate without any major problems.
- According to the monitored results, obtained by Ontario Hydro between the fall of 1982 and the spring of 1985, the heat pumps initially provided 2.5 units of energy for every unit used (COP of 2.5). This was lower than the design COP of 2.75 because the circulation of water through one of the heat pump's distribution networks was partially blocked for several weeks. Over the longer term, a seasonal COP of 2.7 ± 0.2, is being achieved.
- The equipment is a self-contained unit so the installation presented no problems. Also, since it was a retrofit system, there was no trouble involved in connecting the heat distribution system.
- Installation of the vertical-loop heat collectors did, however, cause a few delays:
  - There was only limited space for the drilling machine, which meant installation took longer than had been anticipated.
  - Groundwater flooded the trenches for the pipe connecting the vertical pipes to the heat pumps. With the aid of a submersible pump, this problem was rectified.

Technical Details:

Arc Rental's premises in Toronto, Ontario consisted of two oil-heated commercial buildings with a combined floor space of 1,100 m^2 (12,000 ft^2). Until 1982, one of the buildings was insulated and heated throughout, while the other was not insulated and was only partially heated. The cost of heating oil amounted to $12,000/year in 1982. The two buildings are heated by radiant hot water piping installed in the floor slabs plus forced-air fan coil unit heaters. Two 634 MJ/hr (600,000 Btu/hr) hot water boilers were in operation while the third acted as stand-by.

An energy audit was undertaken by Cantherm Heating Ltd. After evaluation of the building's heat losses, two Cantherm heat pumps (Model DUO 1200) were installed. At the same time, the insulation in the buildings was upgraded.



The schematic diagram illustrates the system. The thermal collectors consist of a bank of closed-looped polyethylene pipes. These are installed in series in vertical configuration at depths of between 83 m and 107 m (275 to 350 ft) in a mixed formation of limestone and clay. A glycol solution is circulated through the tubing to extract heat stored in the ground. The solution gives up the heat to the refrigerant in the heat pump evaporators. Circulation pumps are contained within the heat pump enclosure.

The heat from the refrigerant is transferred to water, which circulates through the radiant heating system in the floor slabs and through forced air unit heaters to heat the building.

For summer cooling, the heat pumps are shut down and a heat exchanger between the ground loop and the forced air unit's loop is operated. In this manner, heat is extracted from the buildings and injected back into the ground.

The amount of heat transferred from the ground to the collector depends on the properties of the soil or water. The heat conductivity of the soil must be accurately determined by an experienced system designer. The following factors affect the design of the ground collector system: the heat pump power demand, the building's energy demand, and the regeneration of the ground temperature on an annual basis. If the collector system is not designed correctly, excessive moisture migration occurs and cracks in the ground can result. Over a longer term, if the temperature of the ground is depleted, the overall efficiency of the system will decline.

Economic Analysis:

Ground-source heat pump systems are most appropriate for new facilities, or in facilities where the existing heating/cooling system requires replacement. The economics associated with ground-source heat pumps are highly dependent on site-specific factors.

The total installed cost of this installation is detailed as follows:

Equipment and Material Cost:

2 DUO 1200 units	$18,126
Polyethylene pipe 3.8 cm (1,158 m)	3,900
14 U-Bends	1,260
Glycol (mixed)	2,000
Subtotal	$25,286

Installation Cost:

Drilling for vertical loop	$16,000
Trenching	2,500
Labour	10,400
Truck expenses	3,000
Subtotal	$31,900
Total	$57,186

The system supplier calculated that, following the improvement in insulation levels, the annual energy load of the building for both heating and cooling is 231,000 kWh (831,000 MJ) electrical equivalent. The heat pump and passive cooling system have an annual electrical requirement of 79,000 kWh. The resulting savings are 152,000 kWh (546,000 MJ) per year electrical equivalent. At an electricity price of $0.04/kWh, this yields an estimated annual saving in the order of $6,100 per year.

The supplier estimates that similar systems could be installed on a turn-key basis for $50,000 and that a comparable system using a natural gas boiler and an air conditioning system would cost in the order of $23,000.

Using estimates of both costs and savings, an estimated payback period of 4.4 years is obtained ($50,000 - $23,000)/$6,100.

Availability:

This demonstration project was designed by Cantherm Heating Ltd., of Ville St. Laurent, Quebec. Other suppliers may provide similar equipment. Organizations without their own engineering departments may need to hire qualified suppliers or consultants to assist in designing, acquiring and installing such systems.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  Room 606, P.O. Box 2009
  55 St. Clair Ave. East
  Toronto, Ontario
  M4T 1M2
  (416) 973-1608 or
  1-800-387-0733 (toll free in Ontario)

Information on the demonstration project is also available from the equipment supplier:

- Cantherm Heating Ltd.
  (re: ENEROPTIONS)
  8089 Trans Canada Hwy.
  Ville St. Laurent, Quebec
  H4S 1S4
  (514) 334-4870

Heating With Municipal Waste

Technology:
Municipal solid waste incineration with heat recovery

Demonstration Project Manager:
Tricil Limited
Garfield and Riverside Drive
P.O. Box 2518
Charlottetown, P.E.I.
C1A 8C2
(902) 892-1085

Location:
Charlottetown, P.E.I.

Annual Savings:
- 3,150,000 litres (700,000 gallons) of imported oil
- 23,500 tonnes (26,000 tons) of MSW diverted from landfill
- $895,000 in operating revenue

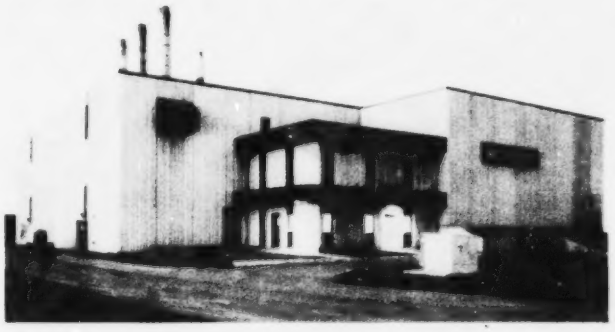
Payback Period: 11 years

Applicable to:
Any municipality able to collect and gather at least 64 tonnes/day of waste in proximity to a large heat/steam user.

Description:
Two Prince Edward Island hospitals are now using energy from Charlottetown's municipal waste.

Prince Edward Island relies very heavily on expensive oil imports for its energy needs. As well, waste disposal was becoming a major concern for P.E.I. and the Charlottetown area, which has a population of 42,000.

To address both problems, Tricil Limited, a private firm specializing in waste management, and the P.E.I. Energy Corporation, a provincial crown corporation, entered into a five year full service contract in May 1981. Under the terms of the turnkey agreement, Tricil was responsible for the design, construction and the initial five years of operation of the energy from waste plant. The facility safely disposes of municipal solid waste (MSW) by burning the waste to generate steam. The steam is sold to two nearby hospitals at an equivalent cost of burning light fuel oil.



Benefits:
The turnkey contract with Tricil provides specific benefits to Prince Edward Island:

- The development and use of a renewable energy source, municipal solid waste, is consistent with a goal of energy self-sufficiency.
- More than 3,150,000 litres (700,000 gallons) of imported oil per year will be saved.
- Requirements for landfilling of waste are significantly reduced. At least 454 tonnes (500 tons) per week of municipal waste formerly landfilled is now reduced in volume by 90% through incineration, thereby reducing landfill requirements.
- Performance guarantees given by Tricil ensure the facility will operate as designed.
- Fabrication capabilities for the energy from waste technology developed on Prince Edward Island could lead to further business opportunities when similar projects are implemented in eastern Canada.
- Canadian content is estimated at 85%.

This ENERGOPTIONS case study provides you with results of this successful project, assisted by the Forest Industrial Renewable Energy (FIRE) and Conservation and Renewable Energy Demonstration Programs. ENERGOPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Technical Details:

The system incinerates up to 98 tonnes (108 tons) per day of municipal solid waste which is converted to approximately 9,100 kg/hr (20,000 lbs/hr) of 2,070 kPa (300 psig) steam utilizing three modular controlled air incineration units and a specially designed heat recovery boiler.

Waste received at the facility is unloaded directly onto a concrete floor inside a large enclosed area. The waste is then mixed and moved as required with a front end loader to one of three hydraulically operated incinerator feeders. They feed the waste into the primary chambers, where transfer rams move the material slowly through the system, which has a stepped-bottom design.

The principle of operation employs a combination of partial pyrolysis and partial combustion in the primary chamber, followed by complete combustion in a secondary chamber.

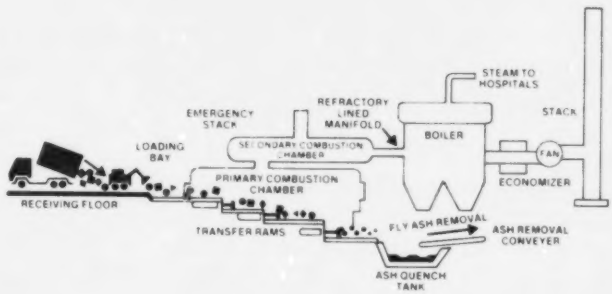
In the primary chamber, air is introduced at low velocity below the refuse bed. The air flow is controlled to permit sufficient combustion of the lower portion of the bed to generate a controlled amount of heat, which dries and pyrolyzes the remaining refuse. The combustible gases produced in the primary chamber pass into the secondary chamber, where preheated air is introduced to allow combustion to proceed to completion. Under normal operation, no auxiliary fuel is required.

Temperatures are controlled at approximately 620° C (1,148° F) in the primary chamber and approximately 980° C (1,795° F) in the secondary chamber.

The fully combusted gases are drawn from the secondary chamber through a water tube boiler by an induced draft fan, which vents the cooled gases to a stack. A bypass emergency stack allows direct venting upstream of the boiler.

The inert ash from the primary chambers is ejected by a transfer ram into a wet-ash tank and conveyed by a drag conveyor to a container box for removal and ultimate landfill disposal.

Results of extensive tests performed recently indicate the system meets all applicable environmental and public health standards. This is without the addition of expensive anti-pollution equipment.



Economic Analysis:

Capital Cost (1982): $9,900,000

Steam Sales	$1,060,000
Tipping Fees (@ $11/tonne)	$ 275,000
Annual Operating & Maintenance Costs:	($ 440,000)
Annual Operating Revenue	$ 895,000

Simple Payback Period: 11 years.

This project also provides significant, but difficult to measure savings to the municipality by reducing landfill operating costs and extending the useful lives of present landfill sites.

Availability:

These modular two-stage incinerators are a proprietary design from Consumat (U.S.A.). Tricil sub-contracted the manufacturing, assembly and installation to on-site contractors.

The Consumat and other designs are currently available in Canada, through suppliers and consultants in major centres.

Further Information:

Further information is available from:

- Tricil Limited
  (re: ENEROPTIONS)
  Garfield and Riverside Drive
  P.O. Box 2518
  Charlottetown, P.E.I.
  C1A 8C2
  (902) 892-1085

- ENEROPTIONS
  Renewable Energy Division
  Energy, Mines and Resources Canada
  580 Booth Street
  Ottawa, Ontario
  K1A 0E4
  (613) 995-9447

- Prince Edward Island Energy Corporation
  (re: ENEROPTIONS)
  P.O. Box 2000
  Charlettetown, P.E.I.
  C1A 7N8
  (902) 892-1051

ENERGY OPTIONS CASE STUDY

QUE FIRE

Sawmill Wood Residue for Lumber Drying

LE BOIS FRANC ROYAL HARDWOOD LTÉE. — BELOEIL, QUÉBEC

Technology:
Wood residue combustion

Project Manager:
Pierre Legault
President
Le Bois Franc Royal Hardwood Ltée.
2095 rue de l'Industrie
Beloeil, Quebec
J3G 4S5

Location:
Beloeil, Quebec

Annual Savings: $112,000

Payback Period: 4.5 years

Applicable to:
Industrial, commercial and institutional users of low pressure steam which have access to wood residues:

- Sawmills
- Wood products
- Institutions
- Greenhouses
- Various industries

Description:
By burning its waste wood to heat its lumber drying kilns, a Beloeil, Quebec sawmill solves both energy and waste disposal problems.

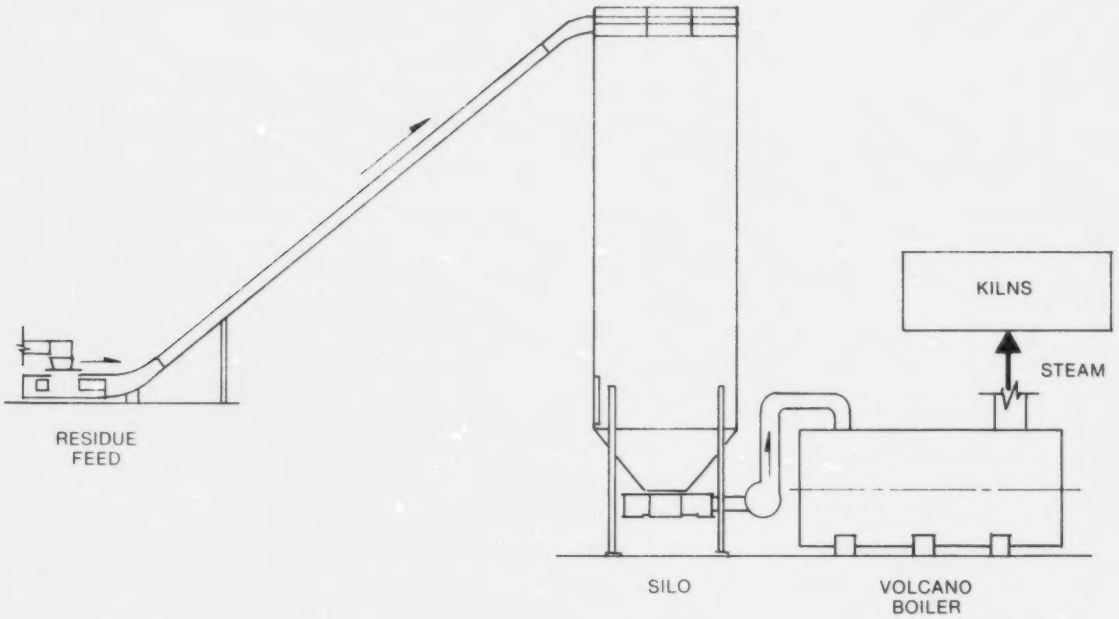
Le Bois Franc Royal Hardwood Ltée. fabricates wood components used in the manufacture of furniture and cabinets. The project involved the conversion of an oil-fired boiler to a wood waste fueled boiler to provide heat to dry lumber . The equipment consists of a Volcano wood waste boiler and ancillary equipment to condition, transport and store the fuel.

Benefits:

- The company reduces its oil requirements by 830,000 L (182,580 gals) per year.
- The system helps to reduce the environmental problem of disposing of wood wastes as landfill.
- Net savings in heating costs reach $112,000 per year.

Technical Details:
The company produces about 5 tonnes (5.5 tons) of sawdust and fine residue daily from machining of wood and another 17 tonnes (19 tons) in the form of blocks, which can be passed through a hammer mill to reduce them to size required for fuel. This residue feeds a Volcano furnace at the rate of 8.8 tonnes (9.7 tons) per day to produce 6,800 kg/hr (15,000 lbs/hr) steam at 105 kPa (15 psig). The steam is used to dry lumber in the kilns.

This ENEROPTIONS case study provides you with results of this successful project, assisted by the Forest Industrial Renewable Energy (FIRE) Program. ENEROPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.



Bois Franc Royal Hardwood

Economic Analysis:

(1981 $)
Equipment Cost: $500,000

	(1981 $)
Annual Fuel Savings	$130,000
Operating and Maintenance Costs	($18,000) approx.
Net Annual Savings	$112,000

Payback Period: 4.5 years.

Availability:

The combustor and steam generator were supplied by Volcano Inc. of St-Hyacinthe, Quebec. This company offers turnkey installation in the sizes ranging from 5 to 250 GJ/hr (4.7 to 237 MBtu/hr) which includes the fuel handling, storage, feeding, combustion, controls and flue gas cleaning equipment. Similar equipment and services are available from suppliers across Canada.

Further Information:

For further information, contact:

- Pierre Legault
  (re: ENEROPTIONS)
  President
  Le Bois Franc Royal Hardwood Ltée.
  2095 rue de l'Industrie
  Beloeil, Quebec
  J3G 4S5
  (514) 467-9271

- ENEROPTIONS
  Renewable Energy Division
  Energy, Mines and Resources Canada
  580 Booth Street
  Ottawa, Ontario
  K1A 0E4
  (613) 995-9447

Arenas and Curling Rinks

Measures:
- Night setback and timers
- Icemaking heat reclaim
- Electrical demand charge reduction
- Energy efficient lighting
- Architectural items

Estimated Annual Saving: $1,500 to $34,000
17% to 55% of pre-demonstration energy consumption

Applicable to:
- Arenas
- Curling rinks
- Winter sports centres

Locations:
Stonewall, Man. — Arena
Neepawa, Man. — Arena and Hall
Carman, Man. — Arena & Curling Rink
Roblin, Man. — Arenas
The Pas, Man. — Arena & Curling Rink
Lorette, Man. — Arena & Curling Rink
St. Leonard, N.B. — Arena
Lameque, N.B. — Arena
Riverview, N.B. — Arena
North Battleford, Sask. — Arena
Yellowknife, N.W.T. — Arena
Pine Point, N.W.T. — Arena

Description:
A number of communities across Canada have implemented cost-effective energy conservation measures in their local arenas and curling rinks.

All the facilities are equipped with systems to reclaim heat from ice-making equipment. Most use this recovered heat to preheat water, while others use the recovered heat for space heating.

Lighting systems are improved in most of the arenas by replacement of incandescent lighting and mercury vapour with more efficient types of illumination such as fluorescent, metal halide or high pressure sodium.

A number of other measures were demonstrated and proven to be cost-effective. Examples include:
- Reduction in peak power consumption;
- Electrical power factor improvement;
- Changes in space heating systems; and
- Selective increases in insulation levels.

Simple measures, such as the following, yield very rapid paybacks:
- Weatherstripping and sealing doors, windows and other cracks in the building shell;
- Insulating steam piping;
- Maintaining minimum ice thickness;
- Night setback thermostats and fan timers; and
- Good operational and general maintenance practices.

Benefits:
- The implementation of a wide range of measures yielded the following estimated reductions in energy consumption at the six Manitoba facilities:

Lorette Sports Centre, Lorette	55%
Roy H. Johnston Arena, The Pas	40%
Roblin & District Arena, Roblin	40%
Carman Community Arena, Carman	32%
Yellowhead Centre, Neepawa	20%
Stonewall Arena, Stonewall	17%

- In the three New Brunswick arenas, heat recovery from icemaking refrigeration equipment, coupled with the conversion to energy efficient lighting sources, saves $4,000 to $10,000 annually, or approximately 25%.
- Changes made at the North Battleford arena in Saskatchewan, are projected to cut energy costs by $17,000 per year, a savings of approximately 30%.
- Incorporation of energy conservation items—primarily, the recovery of heat from the refrigeration plant—at a new arena in Yellowknife, saves an estimated 100,000 litres (22,000 gallons) of oil annually.

ENERGOPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENERGOPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Details:

A wide range of energy conservation measures were demonstrated in these arenas and curling rinks. Details on a number of these measures follow.

Night Setbacks and Timers

Cost-effective energy savings can generally be obtained by using timers and other simple control equipment to reduce space temperatues, shut-off exhaust fans and close dampers in arenas when they are not in use. These types of minor control improvements were made in many of the facilities for payback periods in the range of 1 to 3 years.

Icemaking Heat Reclaim

Heat reclaim is the process whereby heat normally rejected to the outdoors from the refrigeration system is reclaimed for use somewhere else in the building. The refrigerant gas is repeatedly heated, compressed, cooled and condensed into a liquid. In the process, heat must be removed between the compressor and condenser and can be used for:

- Domestic hot water (DHW) preheating;
- Flood water preheating; or
- Space heating.

Variations on this measure were implemented in all of the facilities.

Available monitoring data on the heat reclaim systems indicates they are operating as designed and are achieving estimated energy savings.

Some operators report that maximum heat recovery is achieved by flooding the ice just prior to periods of high recovered heat demand (i.e., just before a game).

Low-Cost Mechanical Measures

A number of no-cost and low-cost improvements were made to the mechanical systems in many of the facilities. These included:

- Following operating procedures designed to minimize energy waste;
- Maintaining the heating and ventilating system in top condition, including regular cleaning of all air filters;
- Reducing domestic hot water temperature;
- Maintaining minimum ice thickness;
- Placing a locking cover over thermostats;
- Repairing dampers and seals;
- Insulating steam pipes; and
- Cycling the brine pump.

Electrical Demand Charge Reduction

The cost for electrical energy can be reduced by improving the power factor associated with the facilities' electrical load. This was accomplished at most of the Manitoba facilities by installing capacitors on large compressor motors. Typically, this measure provided a one- to two-year payback.

Demand costs can be further reduced by reducing electricity consumption during peak periods. This was accomplished in the Stonewall, Manitoba arena by installing a smaller compressor (50 hp) to operate during the winter months and in some other facilities via the use of demand controllers to turn off non-essential loads during peak periods.

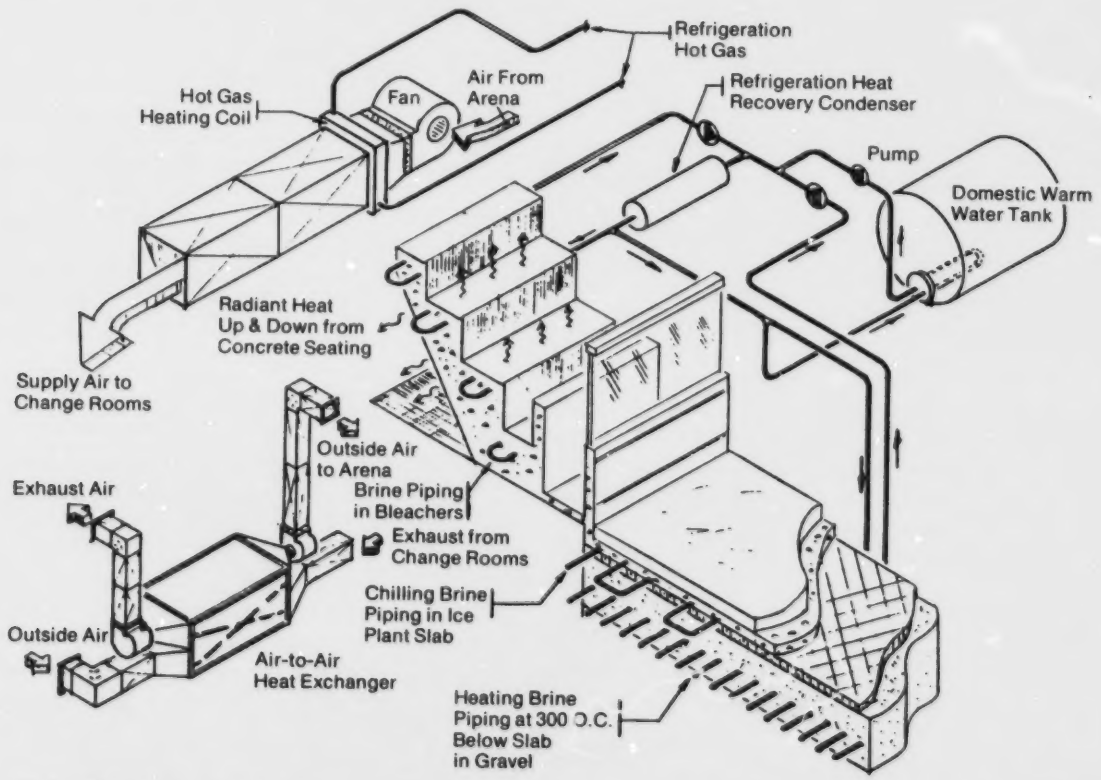

Refrigeration Hot Gas
Air From Arena
Fan
Hot Gas Heating Coil
Refrigeration Heat Recovery Condenser
Pump
Domestic Warm Water Tank
Radiant Heat Up & Down from Concrete Seating
Supply Air to Change Rooms
Outside Air to Arena
Brine Piping in Bleachers
Exhaust Air
Exhaust from Change Rooms
Chilling Brine Piping in Ice Plant Slab
Outside Air
Air-to-Air Heat Exchanger
Heating Brine Piping at 300 O.C. Below Slab in Gravel

Figure 1— Yellowknife Arena Heat Reclaim System

Energy Efficient Lighting
A range of approaches were demonstrated for reducing lighting costs. No-cost and low-cost measures included: establishing guidelines for lighting use, cleaning fixtures, repainting reflectors and removing unnecessary lights and fixtures.

In many of the Manitoba facilities, incandescent lighting in lobbies, change rooms and other general purpose areas were converted to fluorescent. Metal halide lighting is used to illuminate ice surface in Lorette Manitoba and North Battleford, Saskatchewan.

In the three New Brunswick arenas, even greater savings were obtained by replacing mercury vapour arena lighting with high pressure sodium lamps. Use of this long life, highly efficient energy source to increase illumination levels, has been well received by the public.

A light dimming system was also installed in the Riverview, New Brunswick arena. Dimmers were found to be cost-effective only when the buildings were used for a wide variety of purposes. Otherwise, use of selective switching can produce similar results at substantially lower costs.

Architectural Measures
Application of weatherstripping, caulking and sealing on doors, windows and other cracks in the building shell was undertaken in all the facilities. These low-cost approaches for reducing infiltration of cold outside air yielded very rapid paybacks.

Implementing more costly architectural measures such as: adding or upgrading insulation levels, replacing doors, adding vestibules and replacing single glazing with double glazing, was found to be highly dependent on site-specific factors.

Insulation of selected areas of several Manitoba arenas was undertaken and payback periods between 5 and 25 years are estimated. One interesting measure was the insulation of the wall between the arena and the heated lobby. This particular measure saved energy and solved a soft ice problem at the lobby end of the rink.

In general, higher cost architectural measures are only cost-effective if performed in conjunction with other renovation measures.

Economic Analysis:

Implementation of energy conservation measures at these 12 facilities in various parts of Canada provides a good information base on the economics associated with energy conservation retrofits in community arenas and curling rinks.

Estimates of typical costs and payback periods associated with a range of measures are provided below. It should be noted that the actual costs and savings at individual facilities are largely dependent upon site-specific factors.

Mechanical Items	Range of Cost Estimates	Range of Estimated Payback Periods
• Night setback temperature controls and locking cover over thermostat	$100-2,000	1-3 years
• Timer controls or light switch control for exhaust fans	$100-500	1-3 years
• Insulate steam piping	$2,000-4,000	1-2 years
• Repair or replace dampers (backdraft(1), makeup air, exhaust)	$500-3,000	1-2 years
(1) note local codes		
• Heat recovery from ice plant for preheating ice flood and/or domestic hot water	$5,000-13,000	3-10 years
• Heat recovery from ice plant for space heating	$15,000-55,000	5-10 years
Electrical Items		
• Install power factor correction capacitor on compressors	$1,000-1,500	1-2 years
• Install peak demand controllers in facilities with heavy electrical heating loads	$2,000-3,000	2-4 years
• Replace incandescent lighting—in lobbies and change rooms—with fluorescent lighting	$500-1,000	2-3 years
• Convert arena lighting from lower efficiency incandescent or mercury vapour to higher efficiency (high pressure sodium or metal halide)	$7,000-17,000	3-10 years
Architectural Items		
• Tighten building shell by weatherstripping and sealing doors, windows and other building openings	$1,500-2,500	1.5-6 years
• Add insulation to walls and ceilings or replace doors and windows with insulated panels	$500-50,000	5-25 years
• New doors or windows	$2,000-10,000	14-25 years

Availability:

Most low-cost measures can be implemented by building maintenance staff using readily available supplies.

Balancing and tuning of HVAC systems can be performed by HVAC contractors throughout the country.

Selection and design of the most cost-effective heat recovery system, and determination of the most attractive package of higher cost measures for a particular facility, likely require the services of an experienced engineering consultant.

Further Information:

A manual on "Energy Conservation for Indoor Ice Rinks" is available from:

- ENEROPTIONS
  Energy Information Centre
  Manitoba Energy and Mines
  117-234 Donald Street
  Winnipeg, Manitoba
  R3C 1M8
  (204) 945-4154

Individual reports on a number of facilities discussed in this case study are available from the appropriate provincial/ territorial office listed below:

For Facilities in Manitoba

- ENEROPTIONS
  Energy Information Centre
  Manitoba Energy and Mines
  117-234 Donald Street
  Winnipeg, Manitoba
  R3C 1M8
  (204) 945-4154

For Facilities in New Brunswick

- ENEROPTIONS
  Energy Secretariat
  Government of New Brunswick
  P.O. Box 6000
  Fredericton, New Brunswick
  E3B 5H1
  (506) 453-3897

For Facilities in the N.W.T.

- ENEROPTIONS
  Energy Conservation Division
  Department of Public Works and Highways
  Government of the Northwest Territories
  YK Centre, 5th Floor
  Yellowknife, N.W.T.
  X1A 2L9
  (403) 873-7203

Indoor Swimming Pools

Measures:
- Low-cost measures
- Glycol loop heat recovery
- Dehumidification with a heat pump
- Electrical demand control

Demonstration Project Managers:

The Grand Bank Swimming Pool
The BAE Group
P.O. Box 6900
St. John's, Newfoundland
A1C 6B4

The Arnprior Civic Centre
Planning and Works Director
Town of Arnprior
Arnprior, Ontario

The Flin Flon Aqua Centre
E.J. Faraci and Associates
200-330 St. Mary Ave.
Winnipeg, Manitoba
R3C 3X7

Locations:
Grand Bank, Nfld. — Swimming Pool
Arnprior, Ont. — Civic Centre
Flin Flon, Man. — Aqua Centre

Annual Savings: $3,350-$13,770

Payback Period: 1.8 to 20 years

Applicable to:
- Indoor swimming facilities
- Buildings with dehumidification requirements

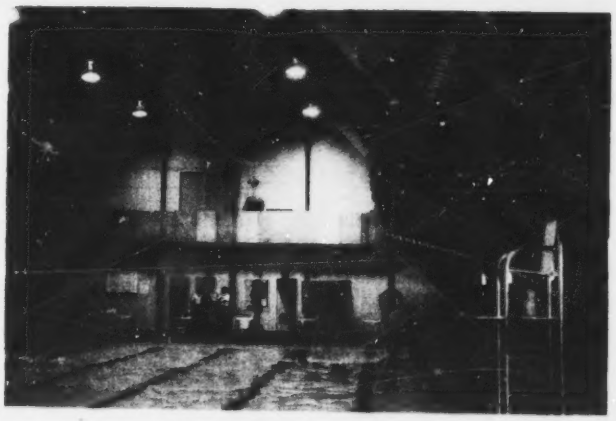
Description:

Three public swimming pools in Manitoba, Ontario and Newfoundland, have implemented energy conservation measures which control pool conditions and operations and save money for the respective municipalities.

The Grand Bank swimming pool, the Arnprior Civic Centre pool and the Flin Flon Aqua Centre have introduced cost-effective measures to control humidity levels and electrical demand. These include:

- The use of a pool blanket to reduce the rate of evaporation;
- A heat exchanger in the ventilation system or a heat pump-based dehumidifier to control the humidity level of the pool area;
- A microprocessor-based unit to control electrical demand.

In addition, several lower-cost measures were undertaken. When the pools are not in use, the pool pumps are turned off and the controls of the ventilation and heating system are set back.



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Benefits:

- No-cost and low-cost conservation items brought immediate savings and paybacks of less than one year.
- Savings of $3,200 to $5,800 a year were achieved by recovering normally exhausted energy with heat exhange or heat pump systems.
- The installation of a Dry-O-Tron unit (a heat pump-based dehumidifier) to reduce the humidity level and recover energy, permits the pool water and building to be maintained at a higher temperature. Pool conditions are now more attractive to families and to particularly the elderly. Also, the use of the unit has retarded the rate of building deterioration caused by high humidity.
- Monitoring of the Grand Bank pool over a 12 month period (May 1984 to April 1985) showed reductions in energy use of 18% to 40% per month, with a 37% reduction in electrical demand — an annual savings of $13,800.

Details:

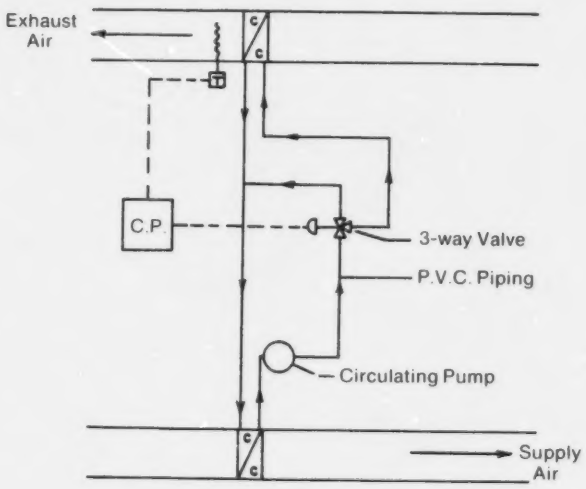
Prior to the installation of the heat reclaim and dehumidification systems, humidity in all the pool areas was controlled by exhausting moist air and replacing it with less moist outside air. Typically, the relative humidity (R.H.) was controlled by a humidistat set for about 60% R.H. When the set point R.H. was exceeded, air was exhausted and fresh, warmed, makeup air was circulated within the pool building.

Pool Blanket

A low-cost pool blanket is used to cover the Grand Bank pool when it is not in use. The floating blanket reduces the rate of evaporation from the pool surface, the humidity level, and the use of costly purifying chemicals.

Glycol Loop Heat Reclaim

At Grand Bank and Flin Flon (see Figure 1) the ventilation system exhausts moist air outside, and dryer outside air is brought in and heated. In Grand Bank, the retrofitted system is either on full recirculation or full exhaust; controlled by high and low humidity setpoints of 65% and 60% respectively, ensuring optimum air flow across the coils and a maximum temperature differential for increased heat recovery. In both systems, heat is transferred from moist exhaust air to a glycol solution in a heating coil. The warm glycol is pumped to a second heating coil in the air intake ductwork, where it warms the intake air and significantly reduces heating requirements. The cooled glycol returns to the first coil again to complete the loop. A frost bypass line and mixing valve are incorporated to bypass the cold glycol around the exhaust air coil when frost starts to develop. Both systems were installed in 1984.



Temperature sensor, it modulates 3-way valve to ensure temperature never goes below 0.6° C (33° F).

C.P. Single input, single output linear controller.

Figure 1 — Glycol heat recovery system

A leak during the monitored period in the Grand Bank fluid recirculation system caused pressure loss problems and a reduction of operating efficiency. Repair of the leak raised the operating efficiency of the glycol system to expected levels. Problems with the dampers were also encountered, accentuating the need for regular inspections and maintenance.

Heat Pump for Humidity Control

The Arnprior Dry-O-Tron air recirculation system, installed in 1981, is illustrated in Figure 2. Pool exhaust air is cooled below its dew point and condensed moisture is removed. The heat liberated by the process provides controlled pool water heating.

Remaining heat is used in the circulating air reheat coil. Air recirculation and dehumidification significantly reduce required heating of makeup air to the building. The unit was installed in August of 1982 and was closely monitored for the first year of operation.

Prior to the installation of the Dry-O-Tron System at Arnprior, studies indicated that savings of 47% were to be expected. Before and after monitoring documented an annual savings of $3,353 per year or 22%. The difference between the predicted and actual savings is due in part to the increase in pool temperature from 26.7° C. (80° F) to 28.9° C (84° F) made possible by the installation. Arnprior traded savings for additional comfort.

Some problems were experienced in interfacing and controlling the original heating system and the Dry-O-Tron system at Arnprior, and there was a problem of low-water pressure supply for pool water heating. These problems were resolved by changing the controllers and adding a water pump.

Demand Controllers

A demand controller was installed in the all-electric Grand Bank pool. To limit demand charges during periods of peak power consumption, this microprocessor-based unit switches off non-essential loads such as pool heaters.

Low-cost Measures
Significant savings at low cost are realized by turning off the pool pump at night, lowering temperatures of areas during unoccupied periods and setting guidelines for the operation of air handling units.

Other Site-specific Measures
A detailed review of the relative costs of propane and electrical energy at Flin Flon led to the recommendation that all heating equipment (except the pool heaters) be converted from propane to electric.

A roof reinsulation program at Flin Flon was essential as the existing spray-on insulation was in poor condition. The new exterior insulation produced sufficient savings for a 20-year payback over and above the functional improvement.

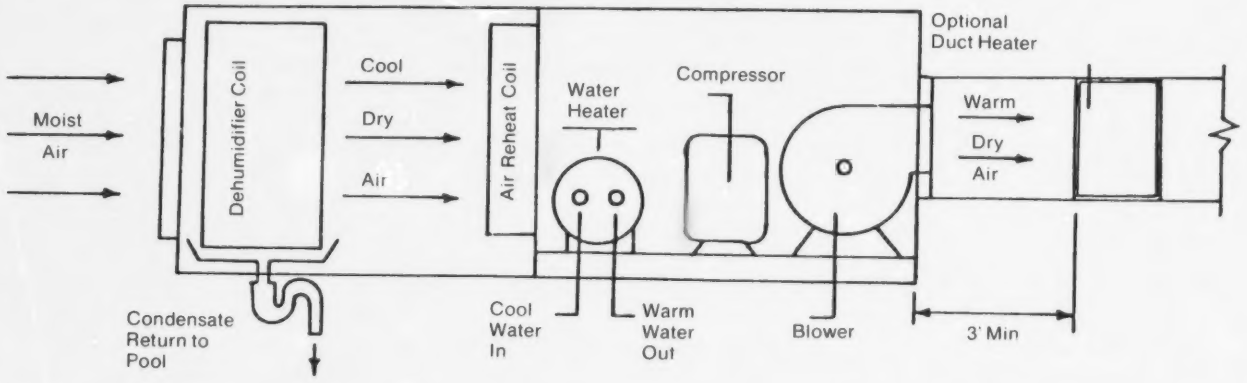


Figure 2 — Heat pump dehumidifier

Economic Analysis:

It must be noted that these costs and savings are highly dependent upon site-specific factors.

Grand Bank

Item	Capital Cost	Annual Savings	Simple Payback Period
Night setback and pool blanket	$ 3,830	$ 2,120	1.8 years
Glycol heat reclaim	$21,000	$ 5,780	3.6 years
Demand controllers	$21,190	$ 5,870	3.6 years
Engineering	$ 9,090		
	$55,110	$13,770	4.0 years

Arnprior

Item	Capital Cost	Annual Savings	Simple Payback Period
Dry-O-Tron	$55,000	$3,353(1)	16.4 years

(1) The pre-installation estimated savings of $8,820 and payback period of 6.2 years assumed that the pool water and air temperature would not be increased.

Flin Flon

Item	Capital Cost*	Annual Savings*	Simple Payback Period
Glycol reclaim	$10,000	$3,220	3.1 years
Electric heating	30,000	3,500	8.6 years
Roof insulation	49,200	2,440	20.0 years
	$89,200	$9,160	9.7 years

Actual Total Installed Cost: $121,370.

* Flin Flon costs and savings are estimates.

Availability:

- Most, if not all, of the low-cost measures can be implemented by building maintenance staff using readily available supplies.
- The Dry-O-Tron or equivalent system and other components of the dehumidification system and energy management systems are available from HVAC suppliers.
- The glycol heat reclaim system and similar circulating fluid heat exchange systems are also available through HVAC suppliers.

Further Information:

A Manual on "Energy Conservation In Indoor Pools" is available from:

- ENEROPTIONS
  Energy Information Centre
  Manitoba Energy and Mines
  117-234 Donald Street
  Winnipeg, Manitoba
  R3C 1M8
  (204) 945-4154

Individual reports on the facilities discussed in this case study are available from the appropriate office listed below:

For Report on Grand Bank Pool:

- ENEROPTIONS
  Energy Branch
  Newfoundland Department of Mines and Energy
  P.O. Box 4750
  St. John's, Newfoundland
  A1C 5T7
  (709) 576-2411

For Report on Arnprior Civic Centre:

- ENEROPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  Room 606, P.O. Box 2009
  55 St. Clair Ave. East
  Toronto, Ontario
  M4T 1M2
  (416) 973-1608 or
  1-800-387-0733 (toll free in Ontario)

For Report on Flin Flon Aqua Centre:

- ENEROPTIONS
  Energy Information Centre
  Manitoba Energy and Mines
  117-234 Donald Street
  Winnipeg, Manitoba
  R3C 1M8
  (204) 945-4154

Large Recreation Centres

Measures:
- Low-cost measures
- Electrical system & controls
- Icemaking heat reclaim
- Use of lowest cost energy source

Locations:
Brandon, Man. — Sports Complex
Thompson, Man. — Recreation Centre
Yorkton, Sask. — Parkland Agriplex
Scarborough, Ont. — Centennial Centre

Annual Savings: $8,400 - $74,700
(20-36% of previous energy costs)

Payback Period: 2.6 to 9.5 years

Applicable to:
- Swimming pools
- Hockey and pleasure skating arenas
- Curling rinks
- Gymnasiums

Description:

Four municipalities, in Manitoba, Saskatchewan and Ontario proved that cost-effective conservation measures can be successfully practiced in large multi-purpose sports/recreation facilities which normally experience high operating costs.

Brandon's Sports Complex, Thompson's Recreation Centre, Yorkton's Parkland Agriplex and Scarborough's Centennial Centre showed annual energy savings of from 20% to 36% by installing packages of measures with payback periods in the range of 2.6 to 9.5 years.

Details on these measures are grouped into four main areas:
- Electrical systems and controls
- Icemaking heat reclaim
- Use of lowest cost energy source
- Low-cost measures

Benefits:

- Savings of 20% and a 2.6 year payback are estimated for the measures implemented at the Brandon Sports Complex, which includes a pool, arena and racquet courts.
- The initial study of the Thompson Recreation Centre, which includes two arenas and a gymnasium, indicated that energy consumption could be cut by 24% by installing a package of measures with a three year payback.
- Total energy use at the Yorkton Agriplex pool, arena and curling rink, is reduced by an estimated 36% with the installation of measures having an estimated 3.8 year payback.
- Pre and post monitoring for six months at the 9,500 m^2 (102,000 ft^2) Scarborough Centennial Centre showed a 20% reduction in natural gas consumption resulting from compressor heat reclaim.

Details:

The following energy cost saving measures were implemented at the four sports/recreation complexes which house facilities for a wide range of indoor sports activities.

Electrical Systems and Controls
The cost of electrical energy has been reduced with the inclusion of additional electrical systems and controls at the Thompson Recreation Centre and Brandon Sports Complex. The power factor associated with the electrical loads at these facilities has been reduced by installing capacitors on large motors.

Further savings in electrical demand costs have been achieved by reducing electricity consumption during peak periods. This is accomplished through the use of smaller unit heaters at Thompson and by minimizing the use of the second compressor in the ice plant at Brandon. More sophisticated approaches include demand controllers which switch off non-essential loads, such as pool heaters, during periods of peak power consumption.

The use of a microprocessor and direct digital control represents the most intensive approach to automated energy management. This approach, as demonstrated at the Brandon Sports Complex, can control a wide range of items and thus optimize the functions of mechanical equipment.

ENEROPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENEROPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Icemaking Heat Reclaim

Heat previously exhausted to the outdoors is recovered from the icemaking compressor as shown in Figure 1. The refrigerant is heated by the compressor and compressed into a gas. Then the gas is cooled and condensed into a liquid, giving off heat used for space heating and preheating hot water and flood water. The cycle is then repeated.

Where arenas and pools are located in the same complex, large savings in pool heating are possible using recovered heat from the arena compressors. A considerable amount of preheated or dehumidified return air must be used to control the humidity in the pool area and the recovered heat from the compressors is excellent for this purpose. Recovered heat can also be used for the pool water and other hot water requirements.

This opportunity has proven cost-effective at Scarborough and Brandon.

Figure 2 is a schematic illustrating all the heat reclaim mechanisms installed at the Scarborough Centennial Centre. In addition to the direct circulation of warm water between the recovered heat storage tank and the pool air preheat units, heat is also transferred through a plate heat exchanger to a potable water storage tank. Warm water is fed from this tank to the domestic hot water heater. Such multiple-use systems ensure that all reclaim heat can be used effectively. Control features and operator knowledge must be carefully addressed.

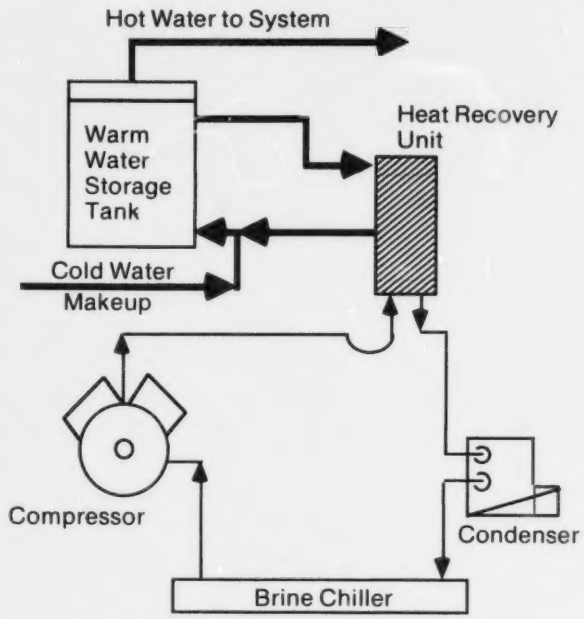


Figure 1 — Typical refrigeration system with heat reclaim

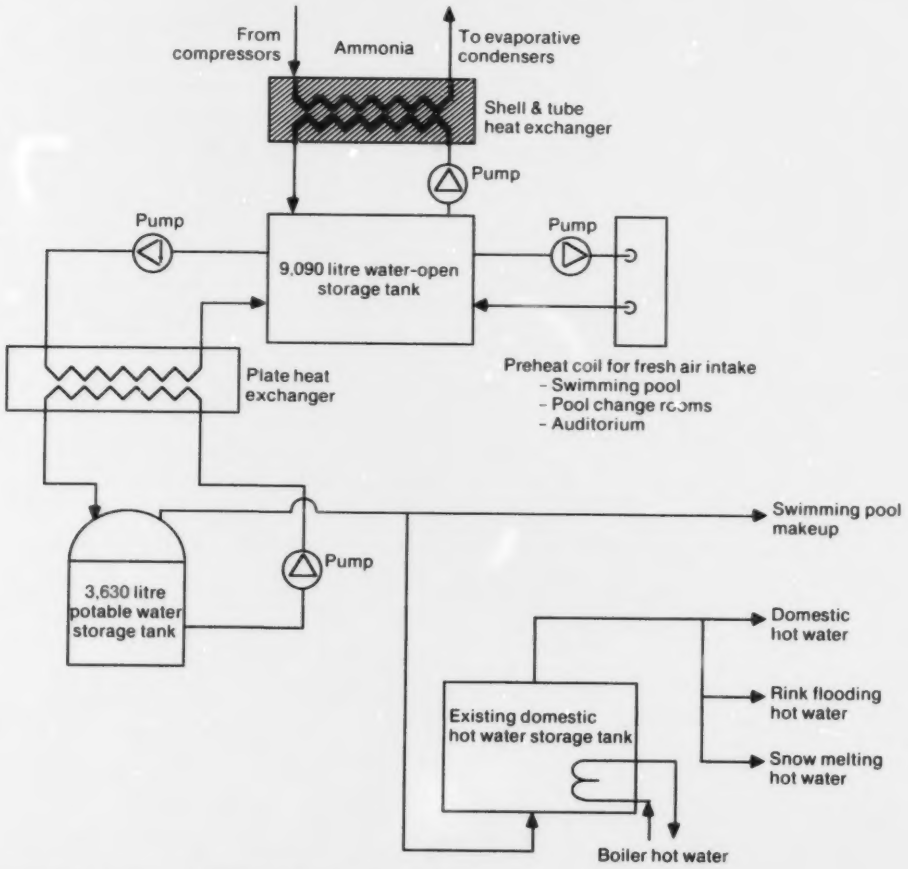


Figure 2 — Scarborough Centennial Centre heat recovery system

The Yorkton retrofit included two 30 kW (100,000 Btu/hr) "Therma-stor" heat recovery tanks — one for domestic hot waters, and the other for ice flooding waters.

Use of Lowest Cost Energy Source
Dollar savings may be achieved by switching to the lowest priced energy source available. The lobby in the Thompson Recreation Centre was converted from propane to electric heat and the boiler in the Brandon Sports Complex from natural gas to electricity.

Low-cost Measures
No-cost and low-cost procedures and items were identified at all facilities, including:

- Reviewing and updating general maintenance procedures;
- Setting and tuning boilers and ventilation controls;
- Balancing or rebalancing ventilation systems;
- Maintenance or weatherstripping, caulking and sealing around doors;
- Delamping or relamping with lowest acceptable wattage;
- Use of night setback thermostat, locks and time clocks;
- Installation of shower flow restrictors or timers;
- Reduced pool overflow to level needed for efficient operation of automatic skimming equipment and sanitation requirements.

Economic Analysis:

The estimated and actual installed costs, annual savings and payback periods associated with the measures implemented in these facilities follow. It should be noted that estimates of costs and savings are often dependent upon site-specific factors.

Brandon

Item	Estimated Capital Cost	Estimated Annual Savings	Estimated Simple Payback Period
Improved maintenance and operational procedures	—	$ 1,400	0.0
Conserve compressor cooling water	$ 1,500	1,200	1.3 years
Power factor correction	3,410	1,100	3.0
Microprocessor energy management system	25,000	8,900	2.8
Icemaking heat reclaim	54,100	20,000	2.7
Electric boiler	5,000	1,200	4.2
	$89,010	$33,800	2.6 years

Actual Total Installed Cost: $135,400

Thompson

Item	Estimated Capital Cost	Estimated Annual Savings	Estimated Simple Payback Period
Low flow shower heads	$ 320	$ 2,000	0.2 years
Night setback	2,000	500	4.0
Power factor correction	3,860	1,100	3.5
Icemaking heat reclaim	61,200	16,600	3.7
Infiltration reduction	19,900	5,500	3.6
Reducing electric unit heater size	500	3,300	0.2
Electric heating for lobby	4,500	2,100	2.1
	$92,280	$31,100	3.0 years

Yorkton

Item	Actual Capital Cost	Estimated Annual Savings	Estimated Simple Payback Period
Balancing HVAC system	$ 2,600	$13,200	0.2 years
Exhaust fan timer and night setback	2,030	4,000	0.5
Ceiling fans — curling rinks	12,310	11,290	1.1
Replace or modify lights	5,440	2,950	1.8
Icemaking heat reclaim	259,900	43,300	6.0
	$282,280	$74,740	3.8 years

Scarborough

Item	Actual Installed Cost	Actual Annual Savings	Actual Simple Payback Period
Icemaking heat reclaim	$79,494	$8,390	9.5 years

Availability:

Most low-cost measures can be implemented by building maintenance staff using readily available supplies.

Balancing and fine tuning of HVAC systems can be readily performed by HVAC contractors throughout the country.

Heat reclaim systems are available from a variety of sources including ice equipment manufacturers.

Selection and design of the most cost-effective heat recovery system and determination of the most attractive package of higher cost measures for a particular facility likely requires the services of qualified technical staff or an experienced engineering consultant.

Further Information:

Manuals on Energy Conservation for "Indoor Ice Rinks" and "Indoor Pools" are available from:

- ENEROPTIONS
  Energy Information Centre
  Manitoba Energy and Mines
  117-234 Donald Street
  Winnipeg, Manitoba
  R3C 1M8
  (204) 945-4154

Individual reports on a number of the facilities discussed in this case study are available from the appropriate provincial office listed below:

For reports on Brandon and Thompson:

- ENEROPTIONS
  Energy Information Centre
  Manitoba Energy and Mines
  117-234 Donald Street
  Winnipeg, Manitoba
  R3C 1M8
  (204) 945-4154

For the report on Yorkton:

- ENEROPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  S.J. Cohen Building
  Suite 706, 119-4th Avenue South
  Saskatoon, Saskatchewan
  S7K 5X2
  (306) 975-4532 or
  1-800-667-9719

For the report on Scarborough:

- ENEROPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  Room 606, P.O. Box 2009
  55 St. Clair Ave. East
  Toronto, Ontario
  M4T 1M2
  (416) 973-1608 or
  1-800-387-0733 (toll free in Ontario)

Large Indoor Pools

Technology:
- Low-cost conservation measures
- Dehumidification
- Exhaust air heat reclaim
- Energy control and management

Demonstration Project Managers:

The Aquarena
BFL Consultants Ltd
P.O. Box 12070
St. John's, Newfoundland
ALB 3T5

Pan Am Pool
E.J. Faraci and Associates Ltd.
200-330 St. Mary Ave.
Winnipeg, Manitoba
R3C 3Z5

Locations:
St. John's, Newfoundland — The Aquarena
Winnipeg, Manitoba — Pan Am Pool

Annual Savings:
Aquarena $95,800 (30%)
Pan Am Pool $40,500 (18%)
(Percentages are savings from previous energy costs)

Payback Period:
Aquarena 3.1 years
Pan Am Pool 2.5 years

Applicable To:
- Large indoor swimming facilities
- Buildings with high dehumidification requirements

Description:
Winnipeg's Pan Am Pool and St. John's Aquarena, both olympic size swimming pools, proved that retrofit measures designed to reduce energy consumption are excellent investments.

Immediate savings were reported as a result of increased-awareness programs and the identification and implementation of no-cost and low-cost energy control and management techniques.

At both pools, major savings were achieved by reducing the amount of heat normally lost in the process of controlling building humidity by exhausting warm humid air and replacing it with heated, drier air from the outside.

At the Aquarena in St. John's, the ventilation system was changed to a recirculating ventilation type, employing heat pump technology to remove water from the recirculating flow.

At the Pan Am Pool in Winnipeg, a system transfers heat from the pool exhaust air into the fresh outside air for preheating, using a circulating glycol heat reclaim system.

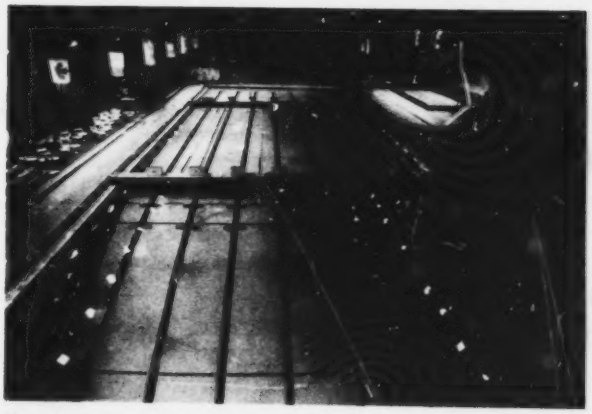


Photo: TEMPOFOTO, St. John's, Newfoundland

The Aquarena swimming pool in St. John's, Newfoundland has implemented retrofit measures which save 30% on the pool's annual energy costs.

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Both systems yield very significant energy savings without the inconvenience of pool blankets or other labour intensive schemes.

Other measures implemented include:

- Shower flow controls
- Automatic management of electrical demand
- Reduction of outside air infiltration
- Modifications and conversions to improve lighting efficiency, and
- Site specific improvements to heating systems.

Benefits:

- Monitoring the all-electric Aquarena has verified annual savings of $45,500 on electrical demand charges, and a further $50,300 savings on consumption charges.
- Modifications at the Aquarena, to the thermostat and humidistat system, improved air distribution and control, while reducing stratification. This results in improved user comfort and energy savings.
- Measures at the Pan Am Pool yielded an estimated 20% reduction in natural gas consumption with only a marginal increase in electrical consumption.
- Increased centralization and automation of controls at both facilities reduced system maintenance costs and energy use due to overuse of manual controls.

Performance:

- Monitoring at the Aquarena was carried out over a two-year period (the year immediately before and the year after system modifications) to quantify a 32.4% reduction in energy use.
- Although changes to the Aquarena specifications were required to stay within budget and the prime contractor defaulted, installation went well and goals for reduction of electrical demand and consumption were achieved.
- The pool superintendent identified a number of minor installation and operational problems at the Aquarena. Most have been corrected, and the few remaining do not significantly affect performance.

Technical Details:

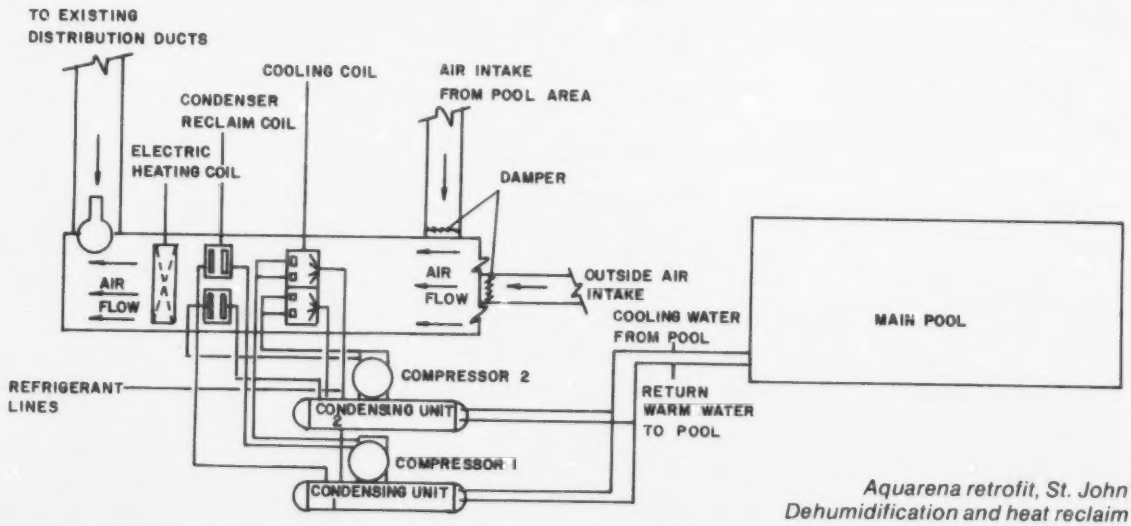
Aquarena

The Aquarena is an A-frame building housing a 2.95 million litre (650,000 gal) main pool, a 64,000 litre (14,000 gal) training pool, a mezzanine, change rooms, administration and utility space. All energy supplied is electrical.

Prior to the installation of the heat reclaim and dehumidification systems, humidity in the pool areas was controlled by exhausting moist air and replacing it with heated, less moist outside air. Typically, the relative humidity was controlled by a humidistat set for about 60% R.H. One of three air makeup units operated continuously, while the remaining two operated in sequence based on a single humidistat reading.

Modifications included replacement of the air circulation system, the addition of a dehumidification and heating system, shower timers, infrared heater timers, electric demand limits and hot refrigerant reclaim.

For the air circulation retrofit, the three existing air handling units were removed and replaced by a single Carrier 39E modular unit, shown in the schematic drawing. This unit draws pool air through a 1.1 m (3.6 ft) duct running the length of the pool area about 10 m (33 ft) above the pool surface. The moist air, at about 26.5 °C (80 °F), is drawn over two direct expansion cooling coils (which lowers its temperature to 15.5° C), and water is removed by condensation. The air then passes over reclaim coils and electric heating coils, which reheat it. This drier air is returned to the pool area.



Aquarena retrofit, St. John's, Nfld.
Dehumidification and heat reclaim system

Hot refrigerant passes through the reclaim coils from the two compressor condenser units, then expands in the cooling coils and returns to the compressor. Excess hot refrigerant passes through separate condenser units, which heat the circulating pool water.

Temperature control elements were relocated from their original location in the air supply discharge to the main pool area. The original manual thermostat system was replaced by automatic controls to achieve an air temperature above the pool surface of 28.3 °C (83 °F), at a relative humidity of 30 to 60 %.

Symmons Industries Inc. "Shower off 60" automatic shower timers, and variable interval timers (up to 60 minutes) were installed. The interval timers control the use of infrared pool deck heaters.

Electrical demand is limited to 756.5 kVA by using an h.o.p. Consulab Inc. peak load regulator. (Previous demand was up to 1,572 kVA.) The regulator sets priorities from highest to lowest for the following:

- infrared heaters
- domestic hot water heaters
- heaters for the training pool
- heaters for the main pool

Tenders were called in September 1980 and the contract was awarded in November of the same year. The complex was reopened and operational by April 1981 and final commissioning was completed in July 1981.

Pan Am Pool

The Pan Am Pool is a large, olympic-size, recreation facility located in Winnipeg.

The conservation program at the Pan Am Pool resulted from a walk-through survey and a discussion with staff. There were high energy losses though improper weather sealing on doors. Specific measures recommended included: removing lamps from overlit areas, cycling the pool pump to extend the filter replacement period, and installation of shower water flow restrictors.

In the initial detailed study of the Pan Am Pool, 19 energy conservation techniques were reviewed, with 12 implemented. Principal measures implemented included exhaust air heat reclaim, low flow shower heads, air infiltration reduction, power factor correction, removing lamps and lamp conversion.

The exhaust air heat reclamation system functions as follows: heat is removed from the moist exhaust air in a heat exchange module and warm glycol is pumped to a second heat exchange module in the intake air ductwork. Cooled glycol is then pumped to the exhaust module to complete the recirculation. The preheated intake air is used for ventilation and humidity control in the pool area.

Interesting additional technical features at the Pan Am Pool included the use of an electric boiler at a high duty cycle, which proved more economical than natural gas, rewiring infrared heaters to limit demand, and correcting the power factor to reduce the demand charge.

Economic Analysis:

In both facilities, studies were initially undertaken to identify appropriate packages of measures. Information on the estimated costs and savings associated with the selected measures is provided. In addition, available actual information, based on monitoring, is provided. It should be noted that many of these costs and savings are highly dependent upon site-specific factors and should be individually evaluated at each potential site.

AQUARENA

Item	Estimated Capital Cost	Estimated Annual Savings	Estimated Simple Payback Period
Air Circulation Retrofit	$110,000	$ 45,600	2.4 years
Heat Reclaim System (Heat Pump)	76,000	36,000	2.1
Control Modifications	26,400	39,400	0.7
	$212,400	$121,000	1.8 years (mean)

Actual Capital Cost

Final Contract	$270,523
Engineering Fees	17,850
Change Orders	7,319
Total	$295,692

Actual Annual Savings

Demand (8,922 KVA @ $4.55)	$40,595
Consumption (1.55×10^6 kWh @ $0.029)	44,950
Retail Sales Tax @ 12%	10,265
	$95,810

Actual Simple Payback Period: 3.1 years.

PAN AM POOL

Item	Estimated Capital Cost	Estimated Annual Savings	Estimated Simple Payback Period
Delamping	$ 45	$ 54	0.8 years
Door Maintenance	520	1,430	0.4
Low Flow Shower Heads	720	9,920	immediate
Infiltration Reduction	30,000	2,385	13.5
Glycol Heat Reclaim	19,650	4,493	4.4
Electric Boiler	13,100	4,117	3.2
Management System	7,800	4,148	1.9
Rewiring Heaters	5,000	10,004	0.5
Power Factor Correction	8,000	2,700	3.0
Fluorescent Lighting	10,400	1,319	7.9
	$95,235	$40,570	2.3 (mean)

Actual Total Installed Cost: $101,620

Availability:

- Most, if not all, low cost measures can be implemented by building maintenance staff using readily available supplies.
- Modular air circulation systems, with compressors and condensers, are available from a number of HVAC suppliers. All other components of the dehumidification system equipment are standard HVAC components.
- Glycol and similar circulating fluid heat exchanger systems are also available from HVAC system suppliers.
- All other hardware employed at both facilities is available through electrical, plumbing, or electronic wholesalers and many retailers.

In selecting appropriate improvements for a particular pool, the services of qualified, in-house engineering staff, or an experienced consultant, would likely be required.

Further Information:

A manual on Energy Conservation For Indoor Pools and a copy of the final report on the Pan Am Pool are available from:

- ENEROPTIONS
  Energy Information Centre
  Manitoba Energy and Mines
  117-234 Donald Street
  Winnipeg, Manitoba
  R3C 1M8
  (204) 945-4154

A copy of the final report on the Aquarena is available from:

- ENEROPTIONS
  Energy Branch
  Newfoundland Department of Mines and Energy
  P.O. Box 4750
  St. John's, Newfoundland
  A1C 5T7
  (709) 576-2411

ENERGY OPTIONS CASE STUDY

SASK 5

Farm Energy Audit Program

PROVINCE OF SASKATCHEWAN

Technology:
Retrofit of agricultural buildings

Demonstration Project Manager:
Energy Conservation Branch,
Saskatchewan Department of Energy and Mines
Regina, Saskatchewan

Location:
Throughout Saskatchewan

Annual Savings:
- Potential savings averaging $1,860 per farm (25% of building energy consumption) were identified
- Actual savings amongst farmers implementing measures in first year averaged $2,030

Payback Period: 3 months to 5 years

Applicable to: All livestock farms

Description:
An energy audit service to assist farmers to reduce energy consumption was offered by the Saskatchewan Department of Energy and Mines over a 15 month period from early 1981 to March 1982. A free on-site energy analysis was provided to 41 hog, dairy, and poultry farmers using a computer equipped mini-bus. A special computer software package entitled BARN was developed for the project to analyze a wide variety of energy management practices in heated and ventilated livestock buildings.

The farm audit service is now being offered by Saskatchewan Power Corporation and the Canada Energy Audit Program (CEAP) upon request.

Benefits:
- Energy savings of between 5 and 30% can be realized through retrofit of agricultural buildings on hog, poultry, and dairy farms.
- Indoor environments are improved, resulting in increased animal health and reduced damage to building structure.
- Farm incomes and profitability are improved.

Performance:
Energy audits were performed on 45 buildings on 41 separate farms. On average, potential savings of $1,860 per farm were identified or 25.2% of the producer's annual energy cost, and 21.5% of the producer's annual energy use. Unit costs of energy on the farms audited varied widely from farm to farm. Conservation measures recommended had a maximum payback period of 5 years and did not cause any inconvenience to the producer or adversely affect animal health. In almost all cases, building conditions were improved by conservation measures.

Of the 103 individual conservation measures recommended in the audits, 26 had been fully implemented by some 15 farmers when an evaluation was performed approximately one year later. (An additional 8 measures were partially implemented and 37 were scheduled for implementation.) These 26 completed measures represented energy savings totalling $30,450. The average saving per measure implemented was about $1,170 per year and the average saving amongst the 15 farmers was $2,030 annually.

Hog operations showed the highest percent savings (30%) but poultry operations showed the highest dollar savings.

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The most frequently recommended and implemented measures were:

- the addition of insulation; and
- the installation of heat recovery equipment.

Other recommendations included:

- reduction in ventilated volume (to match animal requirements),
- temperature set back,
- reduction in operating hours; and
- replacement of inefficient heating equipment.

Energy savings were found to be very dependent on production schedules, animal size, and building size.

The on-site discussions with the operator were an essential part of the audit process. They revealed many potential improvements which the operators might have overlooked.

Minor problems did occur, however, such as the farmers' lack of access to photocopying facilities to make copies of utility bills for the pre-audit questionnaire. The "BARN" computer program was found to be a useful tool in the energy analysis but needed to be refined to include a much wider range of inputs.

Show displays and mailouts were found to be the most successful means for marketing the program. Poultry and hog farmers showed the most interest in audits with 7% and 3% respectively, of the province's producers participating.

Technical Details:

The audit program was offered from a modified commercial van equipped with a Data General Nova 4 computer. Software was developed that would allow the two staff carrying out the audit to analyze energy consumption on-site.

The program was advertised through displays, press releases, mailouts, newsletter articles, and open houses. The client first mailed in a questionnaire and copies of utility bills. When the team arrived on site, an inspection was made with the producer (clean overalls and boots were used at each location to prevent spread of disease). The following tests were then carried out:

- survey of lighting
- measurement of ventilation rates
- inventory of machinery and equipment
- verification of building dimensions and insulation levels
- measurement of temperatures
- test of combustion efficiency

The results were entered into the "BARN" computer program, and the producer was provided with an immediate set of recommendations plus a written report 2 weeks later. Only measures with less than a 5 year payback were recommended.

Economic Analysis:

The potential savings identified for the 41 farms audited are made up of 103 separate measures with a combined dollar value of $76,300 per year (at December 1982 energy prices). This amounted to $1,860 average savings per farm. Of these measures, 25% had paybacks of less than 2 years and 75% were between 2 and 5 years.

Of the 26 measures fully implemented by 15 farmers at the end of approximately one year, the total (projected) savings amounted to $30,450 per year (at December 1982 prices) — or some 40% of the total potential savings. The average measure saved $1,170 per year and the average implementing farm saved $2,030 annually. Of the 26 measures implemented, 23% had paybacks of less than 2 years and 77% between 2 and 5 years.

Availability:

None of the recommended measures involved the purchase of specialized equipment and labour except for heat exchangers which were purchased from Saskatchewan manufacturers. All other materials are readily available from farm suppliers across Canada.

The BARN computer is available to all provincial energy or agriculture departments or utilities. Contact the Saskatchewan Conservation and Renewable Energy Office (CREO) for further information.

In Saskatchewan, the farm energy audit service is available from SaskPower.

The audit service can also be provided, if demand from farmers warrants, as part of the Canada Energy Audit Program (CEAP), available through the Energy, Mines and Resources Canada CREO office in each province.

Further Information:

Further information and a technical report on this program are available from:

- ENEROPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  706-119 4th Avenue South
  Saskatoon, Saskatchewan
  S7K 5X2
  (306) 665-4520
  or 1-800-667-9712 (toll free in Saskatchewan)

Information on the Saskatchewan farm energy audit service is available from:

- Customer Advisory Services
  Saskatchewan Power Corporation
  2025 Victoria Avenue
  Regina, Saskatchewan
  S4P 0S1
  (306) 566-2121

Farm Energy Management Program

PROVINCE OF SASKATCHEWAN

Technology:
Energy efficient farm management practices

Demonstration Project Manager:
Saskatchewan Research Council
30 Campus Drive
Saskatoon, Saskatchewan
S7N 0X1

Location:
Throughout Saskatchewan

Annual Savings: $3,250 per farm

Payback Period: 0-7 years

Applicable to: All farms

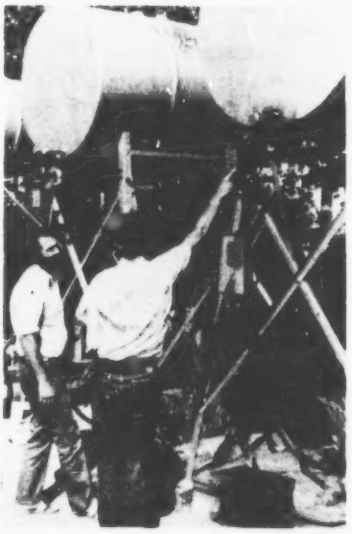
Description:
The purpose of this three-year project was to develop a farm energy management strategy by studying energy use on 22 Saskatchewan farms of varying types and locations. Using farm energy audits, fuel meters and logs, energy use on each farm was recorded and estimates were made of potential savings that would be achieved through upgrading buildings and equipment, alternative machinery operating practices, and alternative cropping practices.

These measures were then implemented and monitored on individual farms in order to test their feasibility and determine their actual costs and savings.

Out of this project, a farm energy management strategy was produced, consisting of the following "building blocks":

- Audit energy use on the farm.
- Evaluate and do small, inexpensive, and easy energy conservation measures.
- Analyze and implement energy conservation measures which require significant investment but offer attractive returns.
- Improve energy efficiency in farm production practices.
- Calculate short-term and long-term economic effects of major changes in cropping systems.

The energy management system developed is being widely publicized among Canadian farmers. The success of the demonstration has resulted in its extension to 50 farmers and to the provinces of Alberta and Manitoba by ENERDEMO-Canada.



Photos: Saskatchewan Research Council

Keeping track of fuel. Fuel meters were installed on all gasoline and diesel fuel storage tanks on the participating farms to help record their use of fuel. A log book was supplied to record fuel volumes, equipment type and farming operations of each refueling.

ENEROPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENEROPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Benefits:

- Average annual energy savings of $3,250 were identified for each of the 20 farms where conservation measures were implemented.
- Payback periods varied from immediate (for no-cost measures) to 7 years, all without loss of farm productivity or efficiency.
- If extended to all Saskatchewan farms, such measures could produce savings of $80 million annually.
- Efficient use of fertilizer and new low-energy cropping practices, (in particular, minimum-till winter wheat production) could generate new income for Saskatchewan farms of over $300 million annually.
- Such savings represent significant cost reductions and increased profitability for farmers.

Performance:

All participating farmers were enthusiastic about the value of energy management after the energy audits were completed and the amounts of energy used directly as fuels and indirectly as fertilizers and herbicides became known. The practice of measuring and recording fuel use alone acted as a stimulus for certain conservation measures.

On average a surprising 42% of all liquid fuels were found to be used for car and truck operation, an average of 17 litres of fuel per hectare. The remaining 58% of fuel use (24 litres per ha) was for farm equipment operation. Crop only farms used slightly less fuel than crop and livestock farms. It was also found that indirect use of energy in the form of synthetic nitrogen fertilizer (produced from natural gas) is approaching the level of direct fuel use. This indirect use was found to be rising much faster than direct fuel use, apparently due to concern about falling soil fertility.

Twenty of the farms receiving audits implemented various elements of an energy management program:

- Eliminating tillage operations on summer fallow resulted in a 4% reduction in tractor fuel consumption for a saving of $200 at no cost.
- The gear-up, throttle-down mode of light-load tractor operation reduced fuel consumption up to 18% for some operations. Annual savings were $450.
- Cars and trucks were used more efficiently by reducing speed and unnecessary use, and by using VHF communication ($1,670 annual fuel savings).
- Farm buildings and residences were upgraded with insulation and heat recovery equipment, and more energy efficient practices such as reduced lighting, temperatures, etc. were introduced. Calculated savings averaged $400 with a payback of 7.3 years.
- Legume plowdown was introduced into crop rotations to reduce nitrogen fertilizer requirements and to save $30 per hectare.
- Deep banding of nitrogen fertilizer was carried out to improve efficiency of use. Extra income was $20 per hectare.
- Optimum rates of fertilizer application were determined.
- Summer fallowing was reduced to cut down fertilizer leeching.
- Stubbling in of winter wheat was introduced to reduce tillage requirements. This yielded $100 more income per hectare than spring wheat.

Seminars held for all participating farmers, agricultural extension representatives, and the farm press were well-attended, well-received, and provided an excellent forum for discussion. Participants were very interested in the aerial photographs used as an aid to energy management.

The project has resulted in a new technique for determining fertilizer application rate based on aerial photographs.

Some problems were experienced with fuel meters. Fuel storage tank meters on low head tanks did not record accurately and the use of on-board fuel efficiency meters for tractors was found to be too expensive.

Technical Details:

The 22 participating farmers were selected on the basis of:

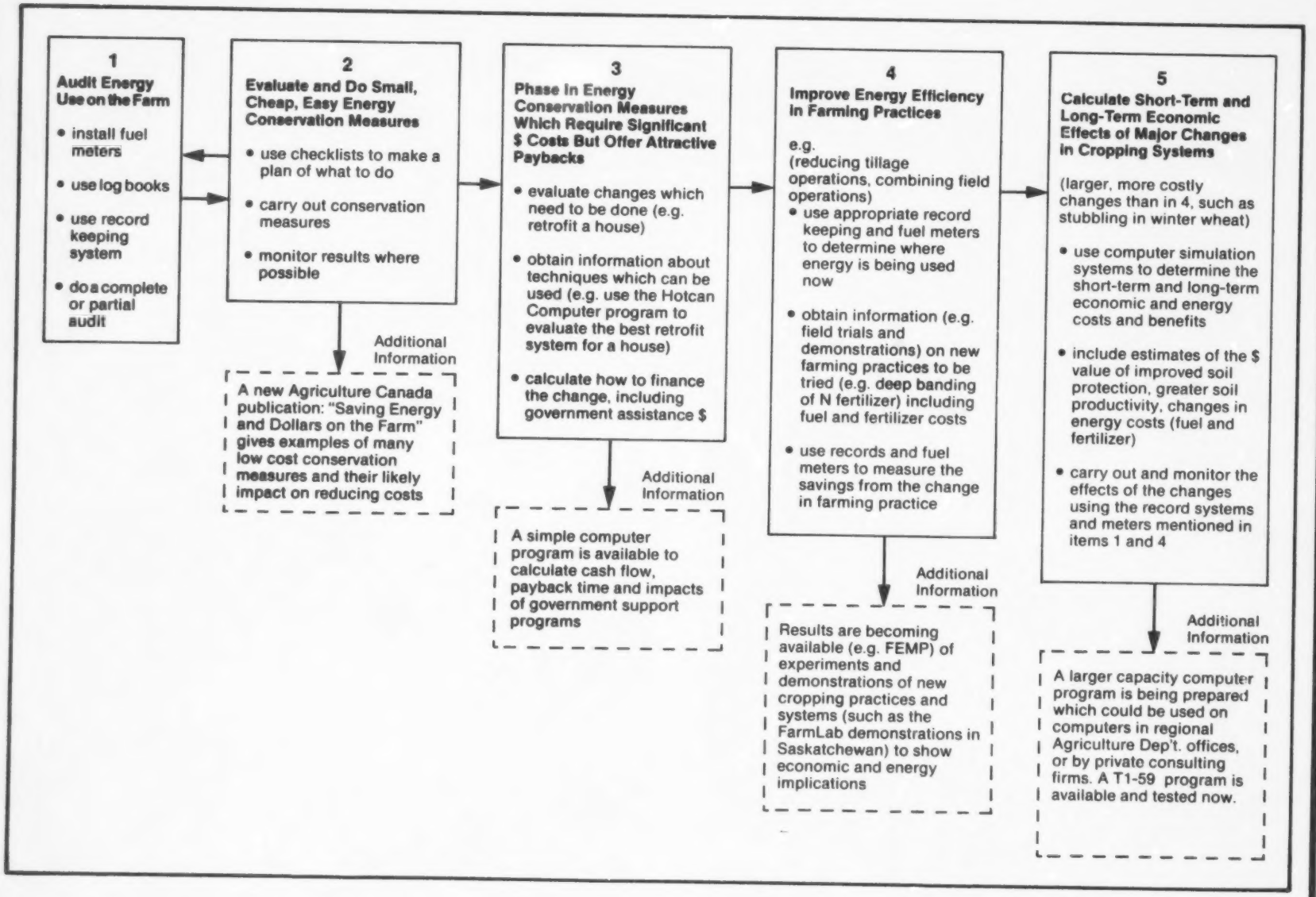
- being innovative and good record-keepers
- regional distribution throughout the province
- variety in types of farming enterprise

The first step in the audit process on each farm was to produce an inventory of buildings, equipment, livestock, and land. Information on crop management practices was also obtained. Each farmer was subsequently supplied with an energy cost analysis.

Detailed surveys of field equipment operations (fuel, fertilizer, and herbicide use) on a field by field basis was carried out. Fuel meters and logs were installed on all gasoline and diesel storage tanks and on diesel tractors. The amount of fuel pumped and the vehicle or machine receiving fuel were logged. Cropping records and heating and electricity bills were mailed in on a regular basis.

A computer program was written to analyse the data and produce energy efficiency indices and plots for use by the project and participating farmers. Technical assistance was given to each farmer developing and implementing an energy management program. Energy use was analysed over a 3 year period from 1981 to 1984.

Annual seminars were held to compare results between participants and for technology transfer via extension personnel. Aerial infrared photographs were taken to aid in energy management and computer models were developed to simulate cropping practices and field fertilizer efficiency.


1
Audit Energy Use on the Farm
• install fuel meters
• use log books
• use record keeping system
• do a complete or partial audit
2
Evaluate and Do Small, Cheap, Easy Energy Conservation Measures
• use checklists to make a plan of what to do
• carry out conservation measures
• monitor results where possible
Additional Information
A new Agriculture Canada publication: "Saving Energy and Dollars on the Farm" gives examples of many low cost conservation measures and their likely impact on reducing costs
3
Phase in Energy Conservation Measures Which Require Significant $ Costs But Offer Attractive Paybacks
• evaluate changes which need to be done (e.g. retrofit a house)
• obtain information about techniques which can be used (e.g. use the Hotcan Computer program to evaluate the best retrofit system for a house)
• calculate how to finance the change, including government assistance $
Additional Information
A simple computer program is available to calculate cash flow, payback time and impacts of government support programs
4
Improve Energy Efficiency in Farming Practices
e.g.
(reducing tillage operations, combining field operations)
• use appropriate record keeping and fuel meters to determine where energy is being used now
• obtain information (e.g. field trials and demonstrations) on new farming practices to be tried (e.g. deep banding of N fertilizer) including fuel and fertilizer costs
• use records and fuel meters to measure the savings from the change in farming practice
Additional Information
Results are becoming available (e.g. FEMP) of experiments and demonstrations of new cropping practices and systems (such as the FarmLab demonstrations in Saskatchewan) to show economic and energy implications
5
Calculate Short-Term and Long-Term Economic Effects of Major Changes in Cropping Systems
(larger, more costly changes than in 4, such as stubbling in winter wheat)
• use computer simulation systems to determine the short-term and long-term economic and energy costs and benefits
• include estimates of the $ value of improved soil protection, greater soil productivity, changes in energy costs (fuel and fertilizer)
• carry out and monitor the effects of the changes using the record systems and meters mentioned in items 1 and 4
Additional Information
A larger capacity computer program is being prepared which could be used on computers in regional Agriculture Dep't. offices, or by private consulting firms. A T1-59 program is available and tested now.

A system for farm energy management (steps 1 to 5 can be done separately or in different combinations).

Economic Analysis:

Many of the energy efficiency measures introduced as a result of the energy management program involved changes to farm practices at no cost to the farmer and with no reduction in production. The payback was therefore immediate. Others which involved investment in building upgrading or equipment tune-up had payback periods of up to 7 years. The average savings achieved on each farm was $3,250 per year.

It is estimated that if the energy management program were practiced by all farms in Saskatchewan, savings of $80 million per year in liquid and heating fuels, and $140 million per year in fertilizers could be achieved.

These savings are significant portions of the $1,200 million net annual income of all farms in Saskatchewan and represent significant opportunities to reduce operating costs and increase farm profits.

Availability:

Most of the energy conservation measures implemented under the energy management program required no specialized equipment or special knowledge.

Federated Co-operatives is now marketing fuel meters and log books to assist farmers in monitoring fuel consumption.

Some of the experimental cropping practices used are still being studied and further refined.

Further Information:

General information on farm energy conservation is available from:

- ENEROPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  Suite 706, 119-4th Avenue South
  Saskatoon, Saskatchewan
  S7K 5X2
  (306) 975-4532
  or
  1-800-667-9719 (toll free in Saskatchewan)

Technical reports on this project are available from:

- Dr. Ewen Coxworth
  (re: ENEROPTIONS)
  Saskatchewan Research Council
  30 Campus Drive
  Saskatoon, Saskatchewan
  S7N 0X1
  (306) 664-5449

Extension bulletins on farm energy management are available from:

- Saskatchewan Department of Agriculture
  1260-8th Avenue
  Regina, Saskatchewan
  S4P 3V7

High Efficiency Indirect Heaters and Air-to-Air Heat Exchangers

PRAIRIE MALT LIMITED — BIGGAR, SASKATCHEWAN

Technology:
- Use of high efficiency indirect heaters
- Utilization of waste heat from drying process to pre-heat drying air

Demonstration Project Manager:
Prairie Malt Ltd.
P.O. Box 1150
Biggar, Saskatchewan
S0K 0M0

Location:
Biggar, Saskatchewan

Annual Savings: $195,776
38% of pre-demonstration kiln fuel cost

Payback Period: 5 years

Applicable to:
A. Industrial drying processes —
- Food processing
- Textile manufacturing
- Agricultural products
- Chemical products
- Fertilizer production

B. Industrial and Commercial facilities that heat large volumes of air —
- Mining industry
- Factory warehouses
- Chemical plants

Description:
Prairie Malt discovered that new energy saving technology improved the quality of their malt and cut energy costs. In 1981, the firm modified their malt drying process by equipping the Biggar plant's number two kiln with high efficiency indirect-fired heaters and air-to-air heat exchangers to replace existing, conventional, direct-fired units. A marked improvement was noted in overall operating efficiency of the modified kiln. The duration of the drying cycle was reduced. There were significant savings in the rate of consumption and the cost of fuel. Some by-products of combustion resulting from direct firing were eliminated. The success of this initial demonstration prompted Prairie Malt to convert a second kiln to indirect-fired heating in 1982.

Benefits:
Compared to conventional indirect-fired heaters:
- Fuel costs are reduced significantly — annual savings of approximately $200,000.
- The fuel consumption rate is reduced by 38% — 1,631,765 m^3 (57,600 Mcf) per annum.

Compared to original direct-fired heaters:
- The air drying cycle is reduced by 2 hours, from 18 to 16 hours.
- Product quality is enhanced and safeguarded.

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Performance:

- The indirect gas-fired heaters are 94 to 98% efficient in converting chemical energy of natural gas into usable thermal energy. The temperature of the exhaust flue gas ranges between 15° C and 40° C (60 to 104° F) during the drying cycle.
- The maximum surface temperature in the heaters is limited to 540° C (1,004° F) compared to 1,200° C (2,192° F) in conventional air heaters thus practically eliminating oxides of nitrogen in the process air.
- In the initial installation, the heaters required constant inspection, adjustment and maintenance. Subsequently, design modifications decreased maintenance requirements. Heaters from another supplier were used in a subsequent installation with no problems experienced with these units.
- The effectiveness of the air-to-air heat exchanger generally ranges between 37 and 81% depending on the stage of the drying cycle and the temperature of the fresh incoming air.
- At very cold ambient temperatures (-40° C) ice buildup on the outside of the air-to-air heat exchanger tubes can occur, thus significantly reducing the effectiveness of the units.

Technical Details:

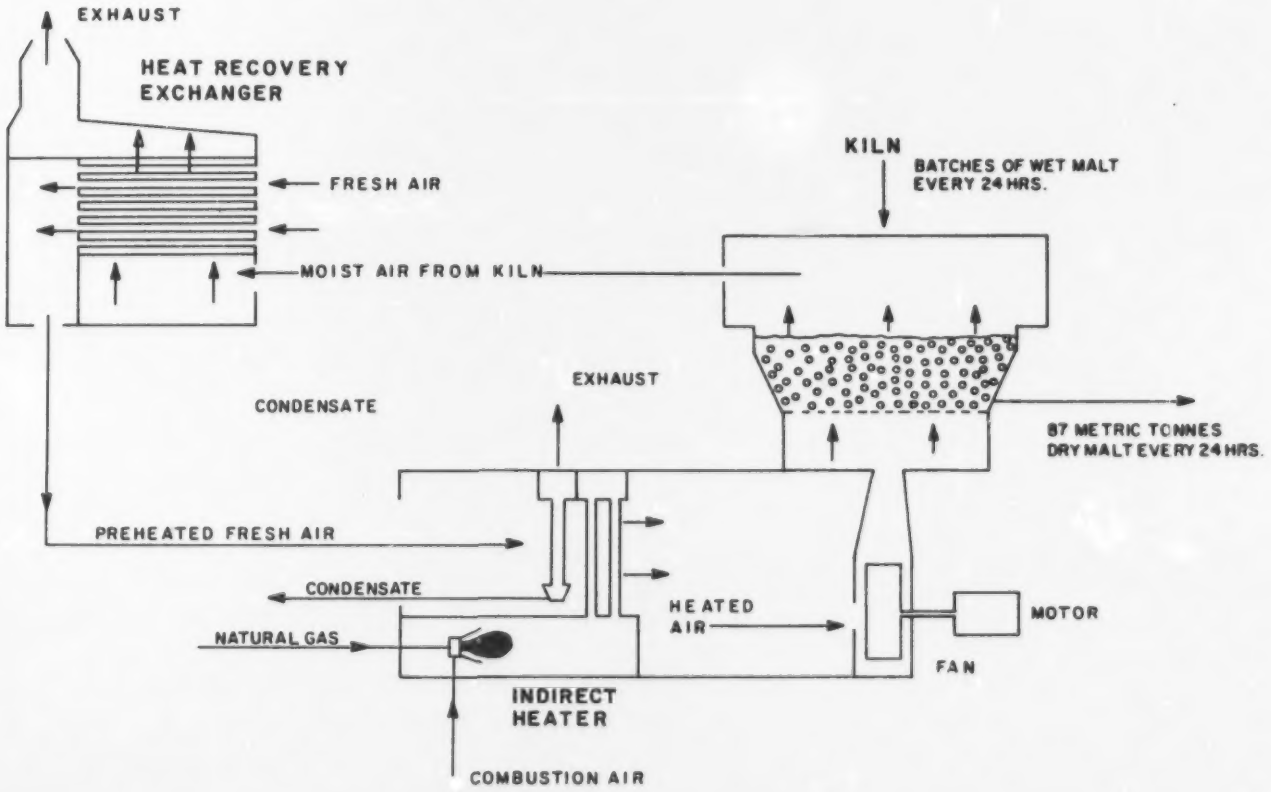
Prairie Malt produces approximately 64,000 tonnes (70,500 tons) of malt per year. The process involves the germination of pre-cleaned barley in a saturated (100% humidity) atmosphere at approximately 18° C (64.4° F) for five days.

The germinated barley or green malt is then dried in a kiln by blowing heated air through a bed for 16 to 18 hours. For every 90.7 tonnes (100 tons) of finished product containing 4% moisture, approximately 68 tonnes (75 tons) of moisture is evaporated, a very energy-intensive process.

In 1981, Prairie Malt modified their drying process in their number two kiln by adding high-efficiency indirect natural gas fired heaters — manufactured by Midland Ross — and Helms air-to-air heat exchangers. This system is illustrated in the schematic diagram.

The higher efficiency of these indirect heaters is derived from using special condensing units which reduce the temperature of the flue gas from approximately 205° C (400° F) to less than 45° C (113° F). A portion of the products of combustion is recirculated through the burner chamber.

Combustion air and natural gas are introduced to the burner. These products of combustion, on leaving the burner, are mixed with the recirculated products. This lowers the temperature of the mixture to approximately 540° C (1,004° F) and reduces the possibility of hot spots on the exchanger tubes. This practically eliminates the formation of nitrous oxides in the process hot air and ensures that minimal nitrosamines are produced in the malt.



During the first 14 hours of the drying cycle, the temperature of the air passing from the kiln to the air-to-air heat exchangers rises from 24°C (75°F) to 77°C (170°F). This air temperature then drops to 72°C (162°F) during the last two hours. The air is generally saturated during the first half of this cycle.

When colder intake air flows through the air-to-air heat exchanger, condensation forms on the warm side. The heat transfer increases many times when compared to a situation where there is no condensation. Therefore, a higher effectiveness of the heat exchanger occurs during the early part of the drying cycle since much latent heat is recovered from the exhaust stream. However, if the ambient temperature drops very much below freezing, ice will form on the exterior of the tubes, reducing the heat transfer rate between the two air streams.

During the last half of the drying cycle, the hot air is at a much higher temperature and is not saturated. This causes the ice to melt and improves the effectiveness of the heat exchanger.

The rated theoretical effectiveness of the heat exchangers is 80%. Provided there is no ice formation on the tubes during the drying cycle (i.e., ambient temperature above -25°C (-13°F)), the actual monitored effectiveness of the units ranged between 37% and 81% during the drying cycle. As noted above, this effectiveness drops off in colder weather due to ice formation.

The air-to-air heat exchangers require little maintenance. The stainless steel tubes have retained their polish after three years of operation. Routine maintenance includes the detection and repair of small holes in the system.

During 10 months of the year little attention has to be given to operating the recovery heat exchangers. However, for two months of the coldest winter weather, two problems arise: if there is an ice fog, the cold air entrance to the tubes tends to plug with hoarfrost. This has to be blown off every few hours with a portable air blower. When the ambient temperature is below -25°C (-13°F), the ice formed on the tubes during the drying cycle doesn't melt thus causing an ice build-up in the heat exchanger. This problem is reduced by passing a portion of the exhaust air from the heat exchanger to the air intake of the indirect heaters.

Based on the satisfactory performance of this unit, the same type of heat exchanger was installed in the second kiln in 1982.

Economic Analysis:

Project Capital Cost ($1982)

Air-to-Air heat exchangers	$917,197
Indirect-Fired air heaters (1)	22,477
Total capital cost	$939,674

(1) Cost of condensing section only; Total cost of heaters was $324,845.

Annual Operating and Maintenance Cost

Pre-demonstration fuel cost (4,330,133 m^3 @ $0.1199778/$m^3$)	$519,520
Post-demonstration fuel costs (2,698,370 m^3 @ $0.1199778/$m^3$)	(323,744)
Net Annual Savings	$195,776

Simple Payback Period: 4.8 years.

Availability:

The indirect heaters employed on the demonstration were supplied by Midland Ross. A number of problems were encountered with these units and have since been rectified by Midland Ross. In a subsequent kiln, Prairie Malt used indirect heaters supplied by Air Frolich which performed well.

Helms of Germany supplied the air-to-air heat exchangers and these units performed well. This firm is one of many that can supply heat exchangers.

The Cambrian Engineering Group provided engineering services. In general, most firms would require the services of a consultant familiar with their particular process.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  S.J. Cohen Building
  Suite 706
  119-4th Avenue South
  Saskatoon, Saskatchewan
  S7K 5X2
  (306) 975-4532 or
  1-800-667-9712 (toll free in Saskatchewan)

Information on the demonstration project is also available from the Consultant:

- The Cambrian Engineering Group Ltd.
  (Re: ENEROPTIONS)
  Att: Mr. E.J. Hinz
  119-105 Street East
  Saskatoon, Saskatchewan
  S7N 1Z2
  (306) 374-8242

Efficient Operation of Farm Tractors

PROVINCE OF SASKATCHEWAN

Technology:
Gear-up, throttle-down operating mode for farm tractors

Demonstration Project Manager:
Department of Agricultural Engineering
University of Saskatchewan
Saskatoon, Saskatchewan
S7N 0W0

Location:
Throughout Saskatchewan

Savings: Up to 18%; approximate fuel saving of 1% for each 1½% reduction in engine speed

Payback Period: Immediate

Applicable to: All farm tractors

Description:

Significant quantities of fuel can be saved when a tractor is loaded to less than 70% of its power, such as with a rod weeder or light-duty cultivator. It can be throttled back to 70 or 80% of its rated RPM and shifted up to a higher gear. This gear-up, throttle-down mode of operation can be applied in one third of field operations and costs nothing.

Field tests were conducted on 16 farm tractors on Saskatchewan farms to determine the fuel savings that can be achieved by the gear-up, throttle-down mode of operation. The tractors were instrumented to provide continuous measurement of drawbar pull, ground speed, engine speed, fuel consumption, and percent wheel slip. After determining fuel consumption under normal operating conditions on each tractor, the engine speed was gradually reduced while maintaining a constant drawbar pull and ground speed.

Benefits:

- Fuel consumption is significantly reduced in the gear-up, throttle-down mode — up to 18% savings were demonstrated.
- Work performance and ground speed were maintained.

Performance:

While there was some variation from tractor to tractor, the gear-up, throttle-down mode of operation at low to medium loading results in lower fuel consumption. A reduction of 15% in engine speed resulted in an average saving of 9% in fuel consumption. A reduction of 30% resulted in an average saving of 18%. The savings were obtained with no loss of work output and would be achieved at any drawbar pull below 70% loading. There was no significant difference in savings between 2 wheel drive and 4 wheel drive tractors.

When operating in the gear-up, throttle-down mode, it is important not to overload or lug the engine. If the engine responds rapidly when the throttle is suddenly opened, the engine is not overloaded.

ENEROPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENEROPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

Technical Details:

The field tests were conducted during 1982 and 1983 on 14 farm tractors throughout Saskatchewan and on 2 tractors owned by the University of Saskatchewan. Four of the tractors tested were four-wheel drive and 12 were two-wheel drive, but one of the latter units also had front-wheel assist. All were diesel tractors.

Five variables were measured during the field tests: fuel consumption (L/hr), ground speed (km/hr), rear wheel speed (km/hr), engine speed (rpm), and drawbar pull (kN). Data were transmitted by cable from the tractor to a mobile instrument van. Voice communication was maintained between the tractor operator and instrument van.

Fuel consumption was measured using a portable fuel meter attached to the tractor. Rear wheel speed was determined indirectly by measuring PTO speed. Ground speed was measured using a fifth wheel with magnetic pick-up. Drawbar pull was measured using strain gauge transducers. A computer provided an output from each test giving fuel consumption in L/hr and L/Ha, mean draft in kN, percent drive wheel slip, ground speed in km/hr, engine speed in rpm, gear number, input and output power in watts, efficiency, and specific fuel consumption in L/kWh.

The tests were carried out on each of the 16 different tractors under varying soil conditions. Each series of tests consisted of a normal operating test plus several at reduced engine speeds.

Economic Analysis:

The average savings from the gear-up, throttle-down practice are approximately 1% savings in fuel for each 1½% reduction in engine speed.

This is a no cost procedure and therefore benefits are immediately realised.

Availability:

No equipment is required to use the gear-up· throttle-down practice.

The procedure is felt to be applicable to all farm tractors in use everywhere.

Further Information:

General information on this and other demonstrations is available from:

- ENEROPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  Suite 706, 119-4th Avenue South
  Saskatoon, Saskatchewan
  S7K 5X2
  (306) 975-4532
  or
  1-800-667-9712 (toll free in Saskatchewan)

Further information, including a copy of the paper "Gear-up Throttle-Down Tests on Saskatchewan Farms" presented to the American Society of Agricultural Engineers (Paper No. NCR83-101) in October 1983, is available from:

- Dr. Gerald Zoerb (re: ENEROPTIONS)
  Head, Agricultural Engineering Department
  University of Saskatchewan
  Saskatoon, Saskatchewan
  S7N 0W0
  (306) 343-3191

Rendering Vapour Heat Recovery System

CANADA PACKERS INC.—MOOSE JAW, SASKATCHEWAN

Technology:
Heat recovery from cooking vapour using a condensing heat exchanger

Demonstration Project Manager:
Energy Technologist
Canada Packers Inc.
95 St. Clair Ave. West
Toronto, Ontario
M4V 1N6

Location:
Moose Jaw, Saskatchewan

Annual Savings: $53,000
20% of cooker fuel costs

Payback Period: 2.7 years

Applicable to:
Industrial users of hot water, with a source of waste process steam:

- Meat processing plants
- Food processing industry
- Textile industry
- Industrial washing applications

Description:

In 1982, Canada Packers installed a rendering vapour heat recovery unit and saved over 20% in energy costs.

Canada Packers has been so impressed with the success of this technology it has since incorporated the unit into its Lethbridge, Alberta plant.

Moisture from the rendering cookers in the form of low pressure steam is removed during the conversion of the inedible waste products to industrial fats and livestock feed.

The period of peak steam production normally coincides with the peak hot water demand for processing and sanitation purposes.

The unit reclaims waste heat from the vapour produced by the four batch inedible rendering steam cookers. The vapour is cooled and condensed with city water in a spiral heat exchanger which preheats the incoming water for processing and sanitation uses. The condensate is discharged into the municipal sewer.

Benefits:

- Annual natural gas savings of 477,000 m^3 (16.84×10^6 ft^3), worth $56,400, were realized by implementing heat recovery from the batch rendering process.
- Large maintenance savings result from the anti-fouling design. A previously installed system was abandoned because of high maintenance costs.
- The quality of the plant's effluent has improved. The lower temperature of the effluent increases the efficiency of fat skimming.

Performance:

- The vapour waste heat recovery system performed well during the five month monitoring period and there have been no unscheduled shutdowns since it went into operation.
- The average heat recovery rate is 3.9 GJ/hr (3.7 MBtu/hr) on the production shift and 1.188 GJ/hr (1.13 MBtu/hr) on the cleanup shift. This lower rate is due to less demand for hot water during the second shift. Based on production data, an average of 54.4 GJ/day (51.6×10^6 Btu/day) was recovered.
- The heat exchanger performed excellently. The heat transfer surface was free from fouling after five months of operation. This indicates that the vapour was sufficiently cleaned of contaminants by the knock-out tank and strainer.

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Technical Details:

The benefits of recovering waste heat from the rendering process were recognized by Canada Packers in 1975 when its Moose Jaw plant was being designed. Initially, a shell and tube heat exchanger was installed, which used the hot discharge water from the steam condensers to preheat city water. This system was unsuccessful due to severe fouling caused by the solids and grease in the plant effluent. It was abandoned in 1978 because it was too costly to maintain.

Due to continued escalation of fuel prices, the company undertook a study in 1980 to determine the feasibility of recovering waste heat from rendering vapour using a condensing heat exchanger. In December 1982, a rendering vapour heat system was installed at the plant. This heat recovery system is illustrated in the schematic diagram.

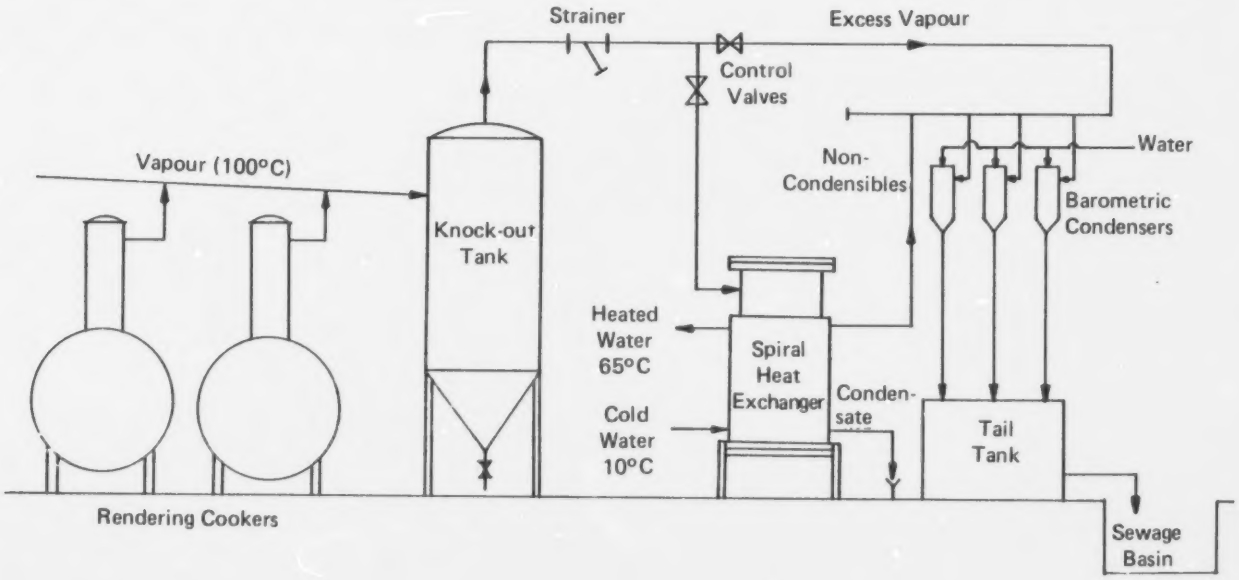
The Moose Jaw packinghouse plant uses a batch process for inedible rendering. Raw material is transferred from the slaughtering operation by conveyors and blow tanks to four steam-jacketted batch cookers. The cookers evaporate the moisture from the by-products and melt the fat, causing it to separate as an oil.

Saturated steam from each cooker passes to an entrainment trap — a vertical tank called the knock-out tank — which removes any solid residue. The steam vapour next passes through a large strainer in the vapour line between the knock-out tank and the heat exchanger. This filters out fine particles and is cleaned once a week to prevent pressure drop.

The clean vapour then passes through a stainless steel, spiral-type heat exchanger manufactured by Alfa-Laval. Vapour flows through in a counter-current direction to the cold water. This configuration causes the vapour to condense and under certain conditions allows sub-cooling of the condensate to about 50° C (122° F), thus maximizing heat recovery. The spiral shape is also designed to reduce the amount of scale formation and to allow for easy access for inspection and cleaning.

In this manner up to 11.1 L/sec (146.6 gpm) of water is heated, typically from 18° C (64° F) to 64° C (147° F).

When the amount of recoverable heat exceeds the demand, the excess steam bypasses the heat exchanger and passes to spray condensers, from which the condensate flows to the sewers.



Economic Analysis:

Project Capital Costs

Heat Exchanger (installed)	$ 37,837
Installation and Auxiliaries	102,908
Total Installed Cost:	$140,745

Net Savings

Fuel Savings (natural gas): (477,000 m^3 @ $0.1182/$m^3$)	$56,400
Less Maintenance Costs	(3,400)
Net Annual Savings:	$53,000

Simple Payback Period: 2.66 Years.

Availability:

The technology is available nationally. The heat exchanger for the demonstration was supplied by Alfa-Laval. The engineering was conducted by Canada Packers' staff. In undertaking a project such as this, smaller firms would likely need the services of an engineering consultant.

The detailed engineering design was prepared by the company's corporate engineering department.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  S.J. Cohen Building
  Suite 706
  119-4th Avenue South
  Saskatoon, Saskatchewan
  S7K 5X2
  (306) 975-4532 or
  1-800-667-9719 (toll free in Saskatchewan)

Information on the demonstration project is also available from the supplier:

- Alfa-Laval Limited
  (re: ENEROPTIONS)
  113 Park Street South
  Peterborough, Ontario
  K9J 3R8
  (705) 745-5735

Greenhouse Heating Using Industrial Waste Heat

TRI-CO FARMS LTD. — REGINA, SASKATCHEWAN

Technology:
Waste heat greenhouses

Demonstration Project Manager:
Tri-Tec Growth Systems
P.O. Box 7343
Saskatoon, Saskatchewan
S7K 4J3

Location:
Tri-Co Farms,
Consumers Co-operative Oil Refinery
Regina, Saskatchewan

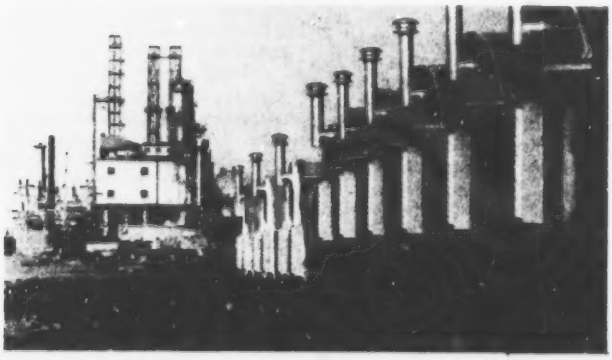
Annual Savings: $28,000
(54% of conventional heating costs)

Payback Period: 3 to 5 years

Applicable to:
Commercial greenhouses located near a source of industrial waste heat.

Description:
Waste heat from an oil refinery is being used to heat a commercial greenhouse.

A 0.4 hectare (1 acre) greenhouse was built in 1982 as a joint venture between Federated Co-operatives Ltd. and Tri-Tec Growth Systems to provide greenhouse vegetables (long English cucumbers and vine-ripened tomatoes) to Saskatchewan markets and to utilize waste heat from the Consumers Co-operative Refinery in Regina. Waste heat is recovered from a refinery products cooler and is used to supply hot



The greenhouses pictured (right) save about 46% of their annual heating costs by utilizing waste heat from the refinery in the background.

Pictured (top) is one of six water-to-air heat exchangers (air handlers) which extract useful heat from oil refinery waste heat.

ENERGY OPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENERGY OPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

water to the greenhouse at between 32° C (90° F) and 65° C (150° F). Natural gas fired unit heaters are used as a backup heating system.

The heating system was operated and monitored over a full heating season from March 1983 to March 1984 using hot water temperatures of 38° C, 45° C and 54° C. The natural gas consumption was measured throughout the period and during a 6 week period in March and April 1983 (when the refinery was shut down for annual maintenance and waste heat was not available). Crop production was monitored throughout the year. A novel retractable insulating blanket curtain, for night-time use, was also tested in the greenhouse.

Benefits:

- Heating requirements are reduced by up to 95% through selection of optimum waste water temperature.
- Crop yields of tomatoes and cucumbers are normal and consumer acceptance is very favourable.
- Industrial plant effluent temperatures are reduced.
- Three full-time jobs and two part-time equivalents were created.
- A viable local business was created based on heat formerly rejected as waste.

Performance

Waste heat system performance may be summarized as follows:

Hot water temperature	Ambient temperature above which waste heat supplies all heating	Natural gas saving
38° C(100° F)	-10° C(14° F)	70%
45° C(113° F)	-20° C(-4° F)	80%
54° C(130° F)	-30° C(-22° F)	95%

Annual natural gas consumption in the greenhouse, without the waste heat system, is estimated to be 420,000 m^3 (14,800,000 ft^3), worth some $52,000.

This projection is based on the 6 week period in March and April 1983 when the refinery was shut down for annual maintenance and the greenhouse was heated entirely by natural gas.

There were no problems with the waste heat system during the heating season.

Some variation in temperatures throughout the greenhouse was unavoidable because it was not possible to synchronize all the thermostats controlling the waste heat air handlers and backup unit heaters. There was also a temperature gradient of 5-7° C between soil and roof levels despite the use of poly-tube hot air distribution ducts at both crop and roof levels.

Crop yields of tomatoes and cucumbers were satisfactory. There was some damage due to high humidity levels and summer scalding because of inadequate ventilation unrelated to the heating system.

The novel insulating curtain, designed to operate during night-time between the two polyethylene glazings, did not operate effectively because of bunching between the arches, and was not used during the testing of the waste heat system. Subsequent tests with new materials were undertaken after the monitoring period.

The polybutylene piping used to circulate water between the refinery and the greenhouses, and within the greenhouse, performed satisfactorily as a pressurized hot water distribution system.

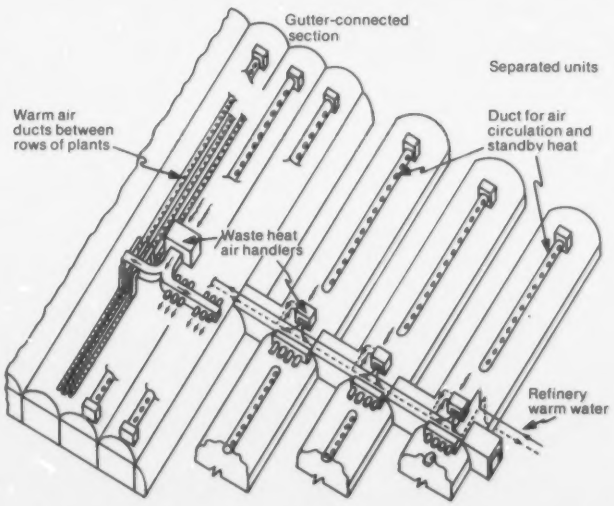
Technical Details:

The greenhouse complex consists of:

- 6 free-standing 9 m × 29 m (30 ft × 96 ft) quonset units with 1 m (3 ft) side walls, and
- 14 gutter-connected 5.5 m × 29 m (18 ft × 96 ft) bays.

A central walk-way connects the gutter-connected bays to the 6 quonset units so that entry to each greenhouse is from the walk-way. The greenhouse walls consist of two layers of 6 mil UV resistant polyethylene with the space between pressurized by outside air.

The waste heat source for greenhouse heating is a vacuum still bottoms cooler in the refinery known as the hot box, which is used to cool the heavier ends of the refinery's product. The maximum heat rejection from the cooler is 24.26 GJ/hr (23 MBtu/hr) with an outlet cooling water temperature of 87° C (190° F) or above. The cooling water is circulated through 500 m (1,600 ft) of underground polybutylene 10 cm (4 in) piping to the greenhouse complex at


Gutter-connected section
Separated units
Warm air ducts between rows of plants
Duct for air circulation and standby heat
Waste heat air handlers
Refinery warm water

Schematic for the waste heat system in the gutter section and separated units.

a rate of 1400 L/min (208 gpm) using a 25 hp pump. The temperature is controlled at between 32° C (90° F) and 65° C (150° F) using a 3-way valve connected to a cold water source. (The maximum recommended temperature for polybutylene piping is 71° C(160° F).

Hot water is circulated through steel and polybutylene piping to 6 water-to-air heat exchangers or air handlers. Hot air is distributed through perforated polyethylene ducts at crop level.

Backup heating is provided by natural gas unit heaters which distribute hot air through a second series of polyethylene ducts at roof level.

The waste heat, backup heating, and ventilation systems are controlled by a microprocessor based on inputs from temperature sensors in each zone of the greenhouses and an outside temperature sensor. The unit heaters are not activated until the outside temperature drops below a set level.

The insulating curtain tested in the quonset greenhouses consisted of aluminized polyester or polyethylene film drawn between the two inflated polyethylene glazings.

Economic Analysis:

Project Capital Costs:

Installed cost of greenhouse complex (excluding waste heat system):	$465,000
Installed cost of waste heat system and warm water pipeline:	$141,000
Total:	$606,000

Annual O&M Costs and Savings

Estimated energy cost without waste heat:	$ 52,000
Actual cost of gas for heating:	($ 24,000)
Estimated annual Savings (54%):	$ 28,000

Simple Payback Period: 5 years.

This analysis assumes a natural gas cost of $0.125/m^3.

The waste water temperature was varied between 38° C (100° F) and 54° C (130° F) during the heating season to determine its effect on percent savings. A sum of $6,400 was also paid for 100% gas heating when the refinery was shut down for maintenance. It was estimated that if the water temperature had been maintained at 54° C (130° F) throughout the heating season and the refinery maintenance shutdown had been in the summer, savings of $50,000 per year (95%) could have been achieved, giving a simple payback period for the heating system and pipeline of under 3 years.

Availability:

All materials used to construct the greenhouse complex, the waste heat system, and the warm water pipeline (except for special materials used for the insulating blanket) were purchased locally and should be available across Canada. No specially trained personnel were required during construction and operation.

Further Information:

A technical report on this project and general information on other demonstrations is available from:

- ENERGOPTIONS
  Conservation and Renewable Energy Office
  Energy, Mines and Resources Canada
  S.J. Cohen Building
  Suite 706, 119-4th Avenue South
  Saskatoon, Saskatchewan
  S7K 5X2
  (306) 975-4532 or
  1-800-667-9719 (toll free in Saskatchewan)

Further information on this demonstration is available from:

- George Green
  (re: ENERGOPTIONS)
  Tri-Tec Growth Systems
  P.O. Box 7343
  Saskatoon, Saskatchewan
  S7K 4J3
  (306) 373-1844

Remote Photovoltaics

TOTAL NORTH COMMUNICATIONS

Technology:
Solar powered (photovoltaic) remote VHF repeater stations

Demonstration Project Manager:
Mr. Gordon Duncan
General Manager
Total North Communications Ltd.
311 Black Street
Whitehorse, Yukon
Y1A 2N1

Location:
3 remote mountain sites in the Yukon and in northern British Columbia

Annual Savings: $6,400 in helicopter service costs
84% of helicopter service costs for conventional system

Payback Period: 1.7 years

Applicable to:
A wide variety of remote radio repeater installations, such as —

- telecommunications
- remote meteorological data collection
- forestry services
- mining exploration
- navigation aids

Description:
Total North Communications Ltd. has successfully stepped into the solar age with the installation of three 75 peak watt photovoltaic (PV) systems with lead calcium battery storage at three mountain top locations in the Yukon and in northern British Columbia. The PV systems were used instead of conventional battery systems at these sites which serve as "line of sight" VHF repeater stations for seasonal mining exploration operations. The lead acid batteries in the conventional stations have to be "swapped out" by helicopter once every two or three weeks — at a cost of $400 to $600 per visit.

The three PV systems have operated reliably for two seasons. Although the direct energy savings are minimal, the maintenance cost savings have been very significant. Site visits, by helicopter, have been reduced from once every two to three weeks to once a season.

Benefits:
The major benefit has been reduced maintenance costs. As a result of the reliable performance of the PV systems, helicopter time for site visits has been reduced by about 16 hours per year — a savings of $6,400. Indeed, it is unlikely that these three communication installations would have taken place if it weren't for the maintenance savings possible through the use of PV power sources.

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Performance:

The equipment, originally installed in summer 1982, has performed above expectations and has proven to be very reliable over several seasons. The panels have shown no sign of deterioration either physically or in terms of performance, despite being subject to very severe climatic conditions. The original mounting arrangement was suitable in terms of wind loading and ease of installation but proved to be unsatisfactory for snow and ice conditions. Snow and ice collected on the panel during the low or no light hours and, when melting occurred, the snow and ice would slide off in sheets and obscure the bottom of the panels. This condition degraded the cells' ability to produce electricity. This problem was resolved by changing the mount to allow a free space between the panels and the ground equal to the maximum snow depth plus 1.5 times the panel height. This allowed the snow and ice build up to fall freely from the panel.

Lead acid batteries were originally used for storage but, after one season, it was clear that they did not have the ability to handle the discharge/charge cycle of the PV system. Once the batteries dipped below one half of their rated output they did not recover, regardless of the charge which was applied. The lead acid batteries were replaced with lead calcium batteries, which have performed well.

Lead calcium batteries provide three important advantages:

- they are a sealed unit — no dangerous gases are produced and no corrosive acid is present
- they are better suited to the charge/discharge cycle associated with the PV system
- they have superior cold weather performance and are not susceptible to freezing.

The PV systems operated efficiently with a duty cycle of 5% to 10%. One site was found to be in heavier use than estimated and an additional solar module was added to prevent deterioration of signals from peripheral areas.

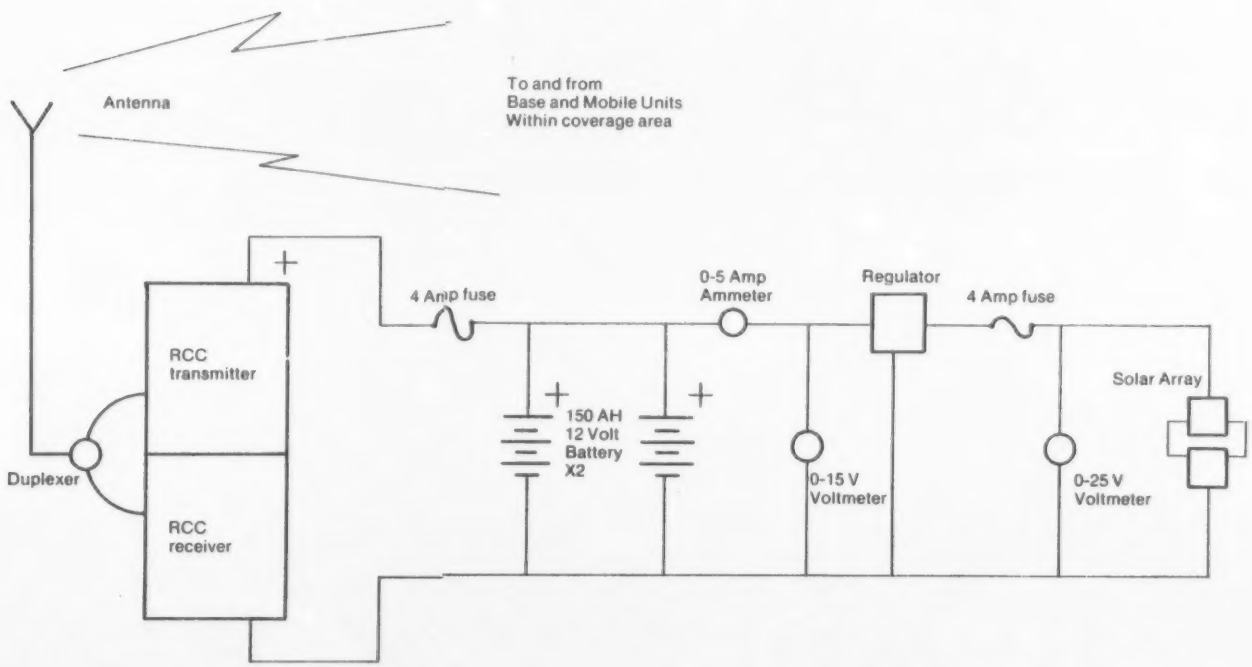
Technical Details:

In order to gain maximum coverage from the repeaters, all equipment was located on the vantage point of each of the mountains.

The electronics and batteries were housed in an enclosure constructed of 2 cm (3/4 in) plywood laminated with fibreglass. The PV panels were attached to the enclosure by an angle iron and were originally mounted directly to the side of the housing with angle iron brackets. The original mount was subsequently changed to allow additional snow and ice clearance.

Two types of PV panels were used — American manufactured ARCO 2300 panels and Canadian TPK panels. The ARCO panels used 10 cm (4 in) diameter cells while 5 cm (2 in) diameter cells were used in the TPK panels. The larger ARCO cells result in a greater density and 16% to 33% greater efficiency.

The solar modules powered two CGE mobile radios which were modified for repeater operation. The modifications consisted of the reduction of transmitter power and the interconnection between the transmitter and the receiver. The mobile repeater configuration was in-line rather than the conventional back-to-back. The figure presents a schematic of one of the sites.



Economic Analysis:

Project Capital Cost

PV panels	$4,669
Regulators	1,224
Misc. hardware	830
Replacement batteries & freight (lead calcium)	985
Total Capital Cost	$7,708
Installation	3,510
Total Installed Cost:	$11,218

Annual O & M Cost and Savings

Pre-demonstration helicopter time (19 hrs @ $400)	$7,600
Post-demonstration helicopter time (3 hrs @ $400)	1,200
Net Annual Savings:	$6,400

Simple Payback Period: 1.7 years.

Availability:

The demonstration units were designed and installed by Total North Communications Ltd. of Whitehorse, Yukon.

PV panels are available throughout Canada from major suppliers of solar equipment.

Further Information:

A final technical report on this demonstration is available from:

- ENEROPTIONS
  Energy Branch
  Department of Mines and Small Business
  Government of Yukon
  P.O. Box 2703
  Whitehorse, Yukon
  Y1A 2C6
  (403) 667-5382

Further information is also available from the demonstration project manager:

- Mr. Gordon Duncan
  (re: ENEROPTIONS)
  Total North Communications Ltd.
  311 Black Street
  Whitehorse, Yukon
  Y1A 2N1
  (403) 668-5175

Pelly Crossing Wood-Chip Furnace

Technology:
Automatic wood-chip boiler

Demonstration Project Manager:
Mr. Al Fedoriak
Maintenance Division
Department of Education
Government of Yukon
P.O. Box 2703
Whitehorse, Yukon
Y1A 2C6
(403) 667-5143

Location:
Pelly Crossing, Yukon

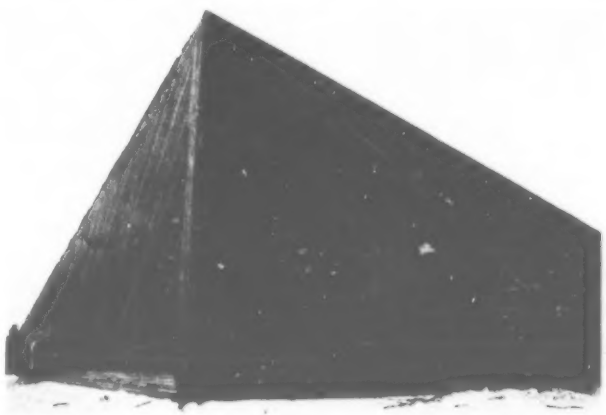
Annual Savings: $11,425
60% net savings on cost of oil heating

Payback Period: 11 years

Applicable to:
Space and hot water heating applications in remote communities —

- Schools
- Hospitals
- Commercial buildings

Description:
A wood-chip heating system in the new school is saving oil and money, utilizing a local resource and providing employment in Pelly Crossing — a small, relatively isolated and predominantly native community approximately 280 km (175 miles) north of Whitehorse, Yukon.
In 1980, approval was received to build a new 1,300 m^2 (14,000 ft^2) school which was also to serve as a community and recreation center. In the original design, the Eliza Van Bibber School was to be heated by two oil-fired boilers. However, in the final design stage a wood-chip heating system, providing both space heat and domestic hot water, was selected as a substitute for the oil system. The biomass system consists of a 350 kW Vyncke wood-chip boiler, an underfed stoker, and a 50 m^3 (1,765 ft^3) silo. Chips are provided from local fire-killed wood using a Bruks wood chipper powered by a diesel tractor. Backup is provided by a boiler and a domestic water heater, both fired by propane.



When the Government of Yukon constructed this new school for the community of Pelly Crossing it chose wood chips as the fuel source.

Benefits:

- The net annual savings from the wood-chip heating system appear to be $11,425 (1984), equivalent to 60% of the cost of operating a conventional, oil-fired system.
- The wood-chip heating system provides significant local economic benefit. Local cordwood is purchased from the Selkirk Indian Band at $60/cord — approximately 1/3 of the equivalent cost of fuel oil. Money formerly spent outside of the community for fuel oil is now spent within the community and provides an important local economic stimulus.

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- The harvesting and chipping of wood has created two local part-time jobs in a community of about 200 plagued by chronic unemployment.
- Both the local wood fuel supply and the wood-chipping system have considerable unused capacity. Further applications of wood-chip heating, as a substitute for conventional oil heating, are being pursued within the community. When implemented, these will further contribute to the local economy by reducing fuel costs, increasing local disposable incomes and creating additional employment.

Performance:

The system is now operating consistently and efficiently. Performance data are being collected and the results of a complete year's operation will be available by June 1985.

The approximate price of delivered heat from fuel oil (@ $0.46/litre) was estimated to be $20.10/GJ, or $19,295 annually (1984). Preliminary estimates indicate that the comparable cost using local wood chips is $8.20/GJ, or $7,870 annually based on: $60/cord for the harvested wood; $1,500 for labour and $450 for operation and maintenance of the chipper; $1,000 for propane backup; and $120 for electricity to power the augers. The 1984 net savings are therefore estimated at $11,425.

During the first few months of operation, a variety of technical problems were encountered. Although the problems were relatively minor they were exacerbated by the lack of technical services available within the community and by the community's remote location. Technical problems were encountered in the following areas:

- wood chip blockages in the auger system
- excessive exhaust fan noise
- system controls

In its initial operation, frequent blockages occurred at the first transfer point in the auger system. These blockages occurred as a result of oversized chips or splinters and the design of the transfer point. During one such incident, the auger itself was damaged. The blockage problem at the first transfer point was overcome by replacing the original corrugated metal sleeve with an angled sleeve made of metal on three sides with a plexiglass front. Greater attention was also paid to achieving uniform chip size. A slip clutch was also installed to prevent damage to the auger or motor in the event of future blockages.

Excessive fan noise was remedied by decreasing the speed of the forced draft fan. This also brought the air supply more in line with optimum levels and increased the overall boiler efficiency.

One of the boiler's safety controls created a minor problem. A sensor located upstream from the exhaust fan measures the flue gas temperature and, if the exhaust temperature is too low, the sensor automatically shuts down the boiler after 25 minutes of operation. The sensor which was installed initially had too high a temperature range and caused the boiler to shut down frequently. A new sensor with a proper temperature range will eliminate the problem.

Technical Details:

The school is a 1,300 m^2. (14,000 ft^2) single-storey building of slab floor construction (built in 1982). In the interests of thermal efficiency, it includes roof insulation of RSI 9.2 (R 52), wall insulation of RSI 3.5 (R 20) and triple-glazed windows. The designed space heating temperature is 21° C (70° F) during occupied hours and 13° C (55° F) during setback hours. The total space heating and domestic water heating requirements are about 960 GJ per year.

Local fire-killed timber is harvested as cordwood by members of the local Selkirk Indian Band and is then chipped on site using a Bruks MTH922 wood chipper powered by a 40 hp John Deere 1040 diesel tractor.

The chips are fed into a 50 m^3 (1,765 ft^3) underground concrete silo, which provides storage capacity for about 10 days during maximum demand periods. The silo is equipped with a heat loop (to prevent freezing) and a live bottom consisting of trapezoidal cylinders, which are pulled across the bottom of the silo by hydraulic pistons in order to supply wood chips to the first of three 30 cm (12 in) diameter fuel augers. A rotary air lock is installed at the second transfer point to prevent burn-back. Burn-back is also prevented by means of a supply of water which will flood the final auger housing should it attain unacceptably high temperatures.

The heating system — a 350 kW Vyncke model WW300S underfed wood chip boiler with automatic feed — was installed during the fall of 1982. Operation began in February 1983.

The boiler is a three-pass vertical fire tube unit, which can be fed either with wood chips through the underfed stoker, or manually with cordwood through its door. An oil burner can also be fitted to an alternate door, if desired. Draft is provided by means of a blower located at the top of the boiler immediately beyond the fire tubes. Fly ash passes from the hearth through the fire tubes and is removed in a cyclone located just beyond the blower. The blower and cyclone are constructed of heavy gauge metal to resist the abrasive action of the fly ash. The boiler is designed to operate with 80% excess air at a combustion temperature of 1,320° C (2,400° F) and with virtually 100% combustion efficiency. Efficient heat exchange is achieved both through direct radiation and through the vertical fire tubes. The exhaust gases exit the boiler at a fairly cool 150° C (300° F) and are relatively clean.

Both the air intake and auger speeds have been adjusted to deliver the maximum requirements of the building. In this manner, maximum efficiency can be achieved during the shoulder periods, when a reduced boiler output is needed. The boiler contains more than 3,000 litres (660 gallons) of water, which stores approximately 120 MJ of heat. This supplies the building's heat requirements between boiler cycles. During normal operation, the boiler runs for about 20 minutes and then shuts down until further heat is required. The hearth will maintain a fire for longer than 24 hours during periods of very warm weather.

Economic Analysis:

Capital Cost:

Vyncke Model WW300S	$ 77,500
Warranty	3,000
Concrete silo & modifications	20,489
Glycol heat loop	4,000
DHW heat exchanger	19,226
Boiler electrical and automatic controls	14,394
Markup	7,908
Miscellaneous	4,684
Sub total:	151,201
Credit (oil boiler and propane backup):	(28,340)
Incremental capital cost for wood-chip system:	122,861
Incremental costs of boiler installation:	5,000
Total Capital and Installation:	$127,861

Annual Operating and Maintenance Costs:

Estimated annual fuel oil savings (41,850 litres @ $0.461):	$19,295
Estimated (annual) wood heating cost:	
• 80 cords of wood @ $60	4,800
• chipper operation and maintenance	450
• labour for chipping	1,500
• propane backup	1,000
• electricity for auger operation	120
	($ 7,870)
Net Annual Savings:	$11,425

Simple Payback Period: 11 years.

Availability:

The system was designed, supplied and installed by Apsco Engineering. Automatic wood-chip heating systems are available through suppliers and consulting engineering firms in major centres throughout Canada.

Further Information:

An interim technical report on this demonstration project is available from:

- ENERGPTIONS
  Energy Branch
  Department of Mines and Small Business
  Government of Yukon
  P.O. Box 2703
  Whitehorse, Yukon
  Y1A 2C6
  (403) 667-5382

Further information on this demonstration project is available from:

- Mr. Jack Dueck
  (re: ENERGPTIONS)
  Apsco Engineering Ltd.
  P.O. Box 270
  Cremona, Alberta
  T0M 0R0
  (403) 264-1049
- Mr. Al Fedoriak
  (re: ENERGPTIONS)
  Maintenance Division
  Department of Education
  Government of Yukon
  P.O. Box 2703
  Whitehorse, Yukon
  Y1A 2C6
  (403) 667-5143

Residential Retrofit of Senior Citizen Housing

YUKON TERRITORY

Technology:
Major and minor retrofit of homes and apartments

Demonstration Project Manager:
Yukon Housing Corporation
303 Jarvis Street
Whitehorse, Yukon
Y1A 3H3

Location:
Throughout the Yukon

Annual Savings: total of $48,000 for 98 units: 10 to 65% of previous consumption

Payback Period: 3 to 15 years

Applicable to:
All single family homes and some types of apartments

Description:
A wide range of residential retrofit measures were implemented in senior citizens' homes and apartments to demonstrate the cost-effectiveness of the measures.

Ninety senior citizens requested an energy audit of their homes and apartments and 56 agreed to retrofit. Four types of retrofit were carried out:

- low-level single home retrofit (caulking, weatherstripping and heating system upgrading)
- medium-level single home retrofit (more insulation, new windows and thermostats)
- major re-wrap retrofit of single homes
- minor and major apartment building retrofit

Each homeowner contributed an amount equal to the estimated first year savings towards the cost of retrofit.

Performing a total retrofit in Whitehorse — Curtain Wall approach.

Benefits:

- Space heating and water heating costs are significantly reduced for senior citizens.
- Home comfort is significantly improved (reduced drafts, improved humidity levels).
- Local contractors received training in energy efficient retrofit techniques.
- Emissions from wood stoves were decreased due to lower heating requirements.
- Over 20 medium and high level retrofits have taken place outside of the project as a result of project activities.

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Performance:

Of the 235 senior citizens approached, 90 requested the free on-site energy audit—slightly lower than anticipated but still a large number to be handled by a single retrofit project. Of those audited, 56 agreed to have the retrofit work carried out.

Many of the homes were more than 20 years old and included a wide variety of building types. Several of the older homes were required to have complete re-wiring along with the retrofit package in order to meet electrical code requirements. However, the addition of curtain walls or Larsen truss walls to homes having a major retrofit did not require special municipal approval.

The level of interest shown by the senior citizens during the retrofit work varied considerably from house to house.

Seventeen journeyman carpenters or experienced contractors completed the 20 day training program in retrofit techniques. More than half of the graduates of the training course gained some work from the project. The requirement that contractors working on the project must complete the 20 day course was not universally accepted across the Territory. Several contractors felt they could not afford the 20 days of time. Enrollment in a special 3 day course arranged for these contractors and other interested persons was not as high as in the 20 day course and few of its graduates have participated in the program. The overall result of the training is that there are now several experienced retrofit contractors in the Yukon who are continuing similar work outside the project.

One source of delays in the project was the involvement of too many agencies in the administration of the project.

The energy audit and recommendations for retrofit were based on a site inspection and measurements followed by estimation of potential savings using the HOTCAN computer program. The 2-3 hour site visit was found extremely useful in showing the homeowner the benefits of a retrofit and in determining where extra time should be allowed for especially difficult retrofit work.

The computer program tended to exaggerate the potential savings that would result from a retrofit. This seemed to be due to the fact that in many of the homes it was difficult to effectively carry out the complete retrofit package because of inaccessible areas and the age of the house. Some contingency should have been included.

The retrofit specifications drawn up for bid on many homes were not detailed enough for accurate tendering. Contractors bidding for the first time on complex work such as house re-wrap required more detailed specifications. The actual retrofit work also required close supervision by the consultant making the recommendations to ensure quality workmanship.

Post-retrofit testing of air tightness and heating requirements was carried out on many of the homes. Air leakage was reduced by between 5 and 50% depending on the pre-retrofit condition and the type of retrofit carried out. Heating requirements were reduced as follows:

- Minor retrofits: 10-25% savings
- Medium level retrofits: 20-35% savings
- Major re-wrap retrofits: 40-65% savings

Monitoring of energy consumption will continue to provide more accurate assessment of the results.

Some homeowners complained of inadequate ventilation after the retrofit was complete. Most, however, were extremely satisfied with the results.

The major lessons learned from this extensive residential retrofit project appear to be:

- savings are less than predicted by the audit;
- retrofit costs are higher than projected—and substantially higher for the major retrofit work;
- payback periods are longer than expected for most levels of retrofit;
- major retrofits are not cost-effective on their own and are only economically justified if undertaken as part of necessary repair and renovation work on a building.

Technical Details:

The audience selected to participate in the project was the 235 recipients of the Pioneer Utility Grant — senior citizens eligible for assistance with utility payments. Letters were first sent out and were followed by personal phone calls.

Energy audits were carried out by a two person team which met with the homeowner and recorded information on house type, size, age, heating equipment, construction details, hot water use, number of occupants, and moisture levels. An infiltrometer was used to obtain an estimate of the size and location of air leakage.

Energy consumption was determined using the Enerkon and HOTCAN computer programs. Retrofit measures were drawn up for the house and the potential savings were estimated using the computer programs. Four types of retrofit packages were specified:

Group 1 Low Level Retrofit:
Caulking and weatherstripping of all accessible air leaks, oil furnace servicing, installation of hot water flow restrictors, storage blankets, and heating system timers.

Group 2 Medium Level Retrofit:
Group 1 measures *plus* upgraded attic insulation, new or upgraded windows, night set-back thermostats, and fresh air ducts into the furnace return air.

Group 3 Major Retrofit:
Group 1 and 2 measures *plus* complete rewrapping of the building envelope, new curtain or Larsen truss walls, air-to-air heat exchanger, and replacement of the heating system.

Group 4 Apartment Building Retrofit:
One apartment complex had a Group 1 and 2 retrofit on its main building (caulking, weatherstripping, attic insulation and a rebalanced heating system) and a Group 3 (external rewrap) on a smaller adjoining building. A second apartment had a complete Group 3 major retrofit including external re-wrap, a new roof, heating system replacement, and a ventilation/heat recovery system.

The work was carried out by local contractors who bid on specifications drawn up for each retrofit. Contractors were allowed to bid if they had CGSB certification to carry out insulation work and had completed the 20 day course in major retrofit put on under the project by Renewable Energy in Canada. To participate in the course a contractor had to be a journeyman carpenter or pass an entrance examination. A shorter 3 day course was also run for contractors unable to spend the 20 days required for the more complete course.

The project was administered by Yukon Housing Corporation. Other agencies involved included: the Energy Branch of the Department of Economic Development, which handled homeowner contacts and financing, the Department of Education which handled training, and the federal Conservation and Renewable Energy Office (CREO) which processed homeowner CHIP and COSP applications.

Homeowners were asked to contribute an amount equal to the first year's potential savings as predicted by HOTCAN but could reduce this through the use of CHIP and COSP grants.

Economic Analysis:

Capital cost of retrofits		**Annual Savings**	
Homes (estimated)	$350,000	Homes (predicted)	$28,000
Apartments	$184,000	Apartments (predicted)	$20,000
Total	$534,000	Total	$48,000

Simple payback period: 11 years (on package of 56 buildings).

The range of costs and percent savings for each Group of buildings was as follows:

	Retrofit Costs:	Percent Energy Savings:
• Group 1: Low level retrofit	$500-$2,000	10%-25%
• Group 2: Medium level retrofits	$3,000-$4,500	20%-35%
• Group 3: Major retrofits (re-wraps)	$10,000-$18,000	40%-65%
• Group 4: Apartment retrofits	$24,000-$160,000	20%-65%

The cost of the training programs was approximately $60,000.

Availability:

All materials and specialized knowledge was obtained locally or obtained through the special training courses on retrofit measures. The courses were designed and taught by Renewable Energy in Canada, 334 King St. E., Suite 206, Toronto, Ontario M5A 1K8, (416) 363-9431.

Energy audits were carried out by Reid Crowther and Partners Ltd., Suite 204, 100 Main Street, Whitehorse, Yukon, (403) 668-3424. Similar services may be available from other experienced energy consultants.

Further Information:

Further information on this project and a copy of the interim report are available from:

- ENEROPTIONS
  Energy Branch
  Department of Mines and Small Business
  Government of Yukon
  P.O. Box 2703
  Whitehorse, Yukon
  Y1A 2C6
  (403) 667-5382

Information is also available from the project manager for the apartment retrofits:

- Don Cosetto
  (re: ENEROPTIONS)
  Yukon Housing Corporation
  205-303 Jarvis Street
  Whitehorse, Yukon
  Y1A 3H3
  (403) 667-5755

Skookum Jim Friendship Centre

Technology:
- Training
- Building retrofit and renovation

Demonstration Project Manager:
Stan Boychuk
Skookum Jim Friendship Centre
3159-3rd Avenue
Whitehorse, Yukon
Y1A 1G1

Location:
Whitehorse, Yukon

Annual Savings:
- almost 75% per unit volume for the Centre
- average 40% for building retrofits

Payback Period: Not applicable

Applicable to:
- Native communities
- Remote communities

Description:

The combination of planning foresight and energy-efficient building technologies has paid off handsomely for Whitehorse's Skookum Jim Friendship Centre and eight Yukon native communities. By 1983 the twenty-two year old native centre was experiencing serious operational constraints due to extremely high energy costs and a general need to expand and upgrade its facilities. At the same time, similar concerns — high energy costs and a need for building upgrading — were being expressed throughout all of the Yukon's remote native communities. Consequently, the Skookum Jim Friendship Centre chose to address both its own immediate needs and those of other Yukon remote native communities in this one project.

The project was conducted in two phases. Phase I of the project stressed proper energy conservation construction techniques. This 8-month segment of the project consisted of both formal classroom training as well as practical "hands-on" experience — by actually retrofitting and renovating the Skookum Jim Friendship Centre.

In Phase II, the newly acquired energy conservation skills of the 10 carpenter trainees were put into practice in each of the 8 participating communities. This Phase of the project served to both demonstrate building retrofit techniques in each community and to provide on-site project management experience for each of the trainees.

Installing fibreglass insulation during a total retrofit in Mayo, Yukon

ENEROPTIONS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENEROPTIONS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

As a result of the project:

- The Skookum Jim Friendship Centre now has a completely renovated, energy-efficient facility which is twice as large as the original facility but costs only half as much to heat;
- More than 40 building energy retrofits and 2 new energy-efficient homes have been completed within the participating communities; and
- Each of the 8 participating native communities now has a trained Band member to assist them in future energy-efficiency improvements to their community buildings.

Benefits:

The project has resulted in substantial direct energy savings and is considered to be an excellent model for energy retrofit training programs in other remote native communities. The specific benefits are:

- The new Centre offers an improved facility for its continuing programs and services. The size of the building has been increased from 850 m^3 (30,000 ft^3) to 1,713 m^3 (60,500 ft^3), yet annual heating costs for the new larger facility are about 50% less than for the original smaller facility;
- Average annual energy savings of about 40% are expected in each of the more than 40 homes retrofitted within the participating communities;
- The 10 carpenter trainees have received extensive practical experience in energy-efficient construction techniques which will be directly applicable to construction activity within their respective communities; and
- The formal classroom training has resulted in the development of curriculum material which will be useful for related future projects.

Performance:

The retrofit training program proceeded as expected and has met its major objectives — improved Centre facilities, participant skills training and improved Band housing.

At the conclusion of the training program, each participant successfully completed a certification exam.

The previous heating costs for the old Centre were about $10,600 annually. The renovated Centre, with double the volume, had an annual heating bill of about $5,000 for 1984. As Phase II of the project was just completed in early 1985, performance data for the Band housing retrofits are not yet available.

Technical Details:

Phase I of the retrofit training program commenced in June 1983. The ten carpenter trainees were selected by the Skookum Jim Friendship Centre in conjunction with local Band councils.

The formal classroom portion of the training program was based on modified curriculum material, originally developed by the Advanced Education Branch of the Yukon Department of Education. The material covered all aspects of energy retrofit as well as low-energy building design and construction techniques.

Practical experience was gained under the supervision of a journeyman carpenter and a site foreman. The actual construction work required on the Centre involved both the retrofit of the existing facility and the addition of a second storey. Consequently, it afforded a practical demonstration of both energy retrofit and new, energy-efficient construction techniques.

Throughout Phase I, emphasis was placed on techniques which were most cost-effective and appropriate for remote communities. For example, in the retrofit of the existing facility:

- Disassembly techniques were demonstrated and the importance of salvaging as a method of reducing materials costs was emphasized;
- A Curtain Wall system was used to retrofit the main floor walls of the original building to an insulation level of RSI 7.7 (R 44);
- The concrete basement walls were insulated on the exterior with RSI 1.8 (R 10) of styrofoam to the footings and double that amount for the top 61 cm (24 in);
- When examples of moisture damage were discovered in the old building, they were used to emphasize proper air and moisture management techniques.

Similarly, during the new construction phase:

- "Double stud-walls" were used on the second storey to gain additional space and allow for RSI 7.7 (R 44) insulation;
- Ten mil polyethylene was used for an air-vapour barrier due to its greater puncture resistance, and proper sealing techniques were demonstrated with particular emphasis given to sealing techniques around doors, windows, plumbing stacks and electrical penetrations;
- A lumber and plywood beam was used as an alternative to dimensional lumber; these can be fabricated in a remote community and are less expensive than long-span, wide-dimension lumber joists;
- Despite the availability of prefabricated trusses, site-built lumber-plywood roof trusses were used as they are the most practical option in remote communities; these featured "high heels" to accommodate RSI 10.6 (R 60) insulation levels all the way to the edge of the wall;
- New vestibules were built at either end of the building to provide buffer zones as people entered during cold weather and to accommodate new stairwells from the basement to the second storey. The vestibules were balloon-framed and insulated to RSI 3.5 (R 20);
- Preserved wood foundations were used for the construction of the new vestibules in order to give the crew experience with a method of basement construction which is less expensive and more appropriate in remote communities. They were insulated to RSI 3.5 (R 20) below grade;
- A cathedral ceiling was constructed on the north vestibule using a modified plywood and lumber beam system which allowed for RSI 10.6 (R 60) insulation;
- Window openings were relocated and strengthened to accommodate the new triple-glazed windows;

- Tyvek was used in place of conventional exterior sheathing;
- The HVAC system consists of two air-to-air heat exchangers interconnected to achieve variable volume air recycling with electric resistance duct heaters to provide zoned temperature control.

Phase II of the project commenced in May of 1984 and was completed on March 31,1985. This Phase involved 4 weeks of intensive retrofit activities in each of the 8 participating communities. Delivery of this project in each community was as follows:

- Several weeks prior to the commencement of activities, the community trainee and one of the course instructors conducted a detailed assessment of all Band-owned houses and prepared a retrofit/renovation plan for each house;
- Based on the individual house assessments, the trainee and instructor prepared a proposed work plan for review and approval by the Band Council. In order to maximize local training and technology transfer objectives, several different levels and types of retrofits were included in each work plan. The actual number of homes to be retrofitted in the 4 week period was determined by the level of retrofits and by the number of local carpenters (in addition to the 10 project trainees and 2 instructors) that the Band Council was able and willing to dedicate to the project. Consequently, the actual number of homes retrofitted in each 4 week period varied from a low of 3 major retrofits to as many as 18 major, medium and low level retrofits;
- In each case, the local trainee assumed the role of project manager and was responsible for all site requirements (e.g., materials procurement, timetable, etc.);
- Approximately 2-3 weeks after the initial site visit, the crew of 10 trainees, 2 instructors and the local carpenters chosen for the task began the intensive 4 week period of work.

This procedure was repeated in each of the 8 communities and in each case the roles of project manager, site foreman, crew boss, etc. were rotated among the trainees. At the completion of the project, each of the trainees returned to their community, where, in many cases, they assumed the role of local Housing Coordinator.

Economic Analysis:

The major objective of this project was technology transfer to the 8 participating remote native communities through skills training and demonstration. Consequently, a substantial portion of both direct and indirect project costs was incurred in meeting this primary objective. The consensus among all parties involved in this project is that this primary objective has been effectively met. Therefore, a conventional economic analysis of only the project's actual retrofit activities would be inappropriate and would seriously undervalue the project's achievements.

Nonetheless, consideration of the project's total costs versus actual and projected energy savings shows very favourable economic returns. Specifically:

- The total cost of Phase I, including the development and presentation of the formal training sessions and supportive audio-visual and written materials as well as all materials and labour for the renovation of the Skookum Jim Friendship Centre, was $355,000. This cost is approximately equal to $710/m² ($66/ft²) for the new facility and compares with a prevailing northern construction cost of about $775/m² ($72/ft²) for a similar facility, constructed to conventional energy standards under normal contracting arrangements. Hence, despite the inclusion of an extensive training component, the new Centre was actually built below market cost. This cost savings resulted from:
  - the Centre assuming the role of general contractor
  - extensive use of salvaged materials
  - labour rates paid to the trainees which were below market rates normally charged by general contractors.
- The total cost of Phase II was $258,000. Approximately 40 native buildings received retrofit measures and 2 new energy-efficient buildings were constructed. Energy savings were from 20 to 60%, with an average savings of 40%.

Availability:

The building materials used are readily available in most of Canada; although, in remote communities, availability of some materials may be restricted and hence alternative techniques may be necessary.

ARCTECH Community Energy Research Associates, a local Whitehorse energy conservation firm, assisted in the building design, presented the formal classroom training and assisted in the delivery of the community retrofits.

Further Information:

Further information and a copy of the final project report are available from:

- ENEROPTIONS
  Energy Branch
  Department of Mines and Small Business
  Government of Yukon
  P.O. Box 2703
  Whitehorse, Yukon
  Y1A 2C6
  (403) 667-5382

Audio-visual and curriculum material developed for the program are available from:

- Stan Boychuk
  (re: ENEROPTIONS)
  Skookum Jim Friendship Centre
  3159-3rd Avenue
  Whitehorse, Yukon
  Y1A 1G1
  (403) 668-4465